JAN 31 1929

In Two Sections—Section One

MECHANICAL ENGINEERING

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

February 1929

800,000 pounds of STEAM per hour from one unit!

N. Y. Times, Dec. 1928

NEW YORK EDISON BUYS 3 RECORD-SIZE BOILERS

Will Drive Largest Single-Unit Generating Machine in World at East 14th St. Plant.

Matthew S. Sloan, president of the New York Edison and associated companies, announced yesterday the closing of a contract with the International Combustion Engineering Company for three boilers that will be the largest ever built. Each will be about as high as an average eight-story building. They are to be installed in the East River generating station of the New York Edison Company at Fourteenth Street and will supply steam to drive the largest single-shaft, single-unit electric generating machine in the world, a 150,000 kilowatt turbo-generator now being built by the General Electric Company.

* * *

The over-all height of the new boilers, which are of the Double Ladd type with fin tube water walls, will be 95 feet, with furnaces 23 feet wide and extending back 65 feet. Each will supply a maximum of 800,000 pounds of steam an hour at a temperature of 700 degrees Fahrenheit, at 425 pounds a square inch pressure. The heighth of the boilers is approximately that of an eight-story building, allowing twelve feet for each floor.

With a heating surface of 60,000 square feet each, the compactness of the battery of boilers will make them not only the greatest producers of steam in the world but also the most economical for the space occupied and the coal consumed. Each of the boilers will require 80,000 pounds of coal an hour, or nearly 1,000 tons daily, if operated continuously at that rate.

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COMBUSTION ENGINEERING CORPORATION

International Combustion Building 200 Madison Ave., New York

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COMBUSTION ENGINEERING

Mechanical Engineering

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J. H. KEENAN

VICTOR P. DOLENGO-KOZEROVSKY

V. E. CLARK

H. N. DAVIS

R. C. H. HECK

Contributors to This Issue

V. E. Clark was graduated from the United States Military Academy in 1907. In 1913 he became an airplane pilot, and the following year took a post-graduate course in aeronautical engineering at the Massachusetts Institute of Technology. From 1915 to 1920 he served in the U. S. Army as chief aeronautical engineer. He served as a member, by appointment of the President, of the National Advisory Committee for Aeronautics in 1917, as a member of the Joint Army and Navy Technical Board for Aeronautics in 1917–1919, and also on the Joint Board for Zeppelins. He was promoted to the rank of Lieutenant-Colonel in 1917 and was the first commanding officer of McCook Field.

As chief engineer for aeronautics for the General Motors Corporation he designed the Amphibian which won the first prize in the U. S. Navy competition in 1922. From 1923 to 1927 he was vice-president and chief engineer of the Consolidated Aircraft Corporation, charged with the design of airplanes and seaplanes.

* * *

R. C. H. Heck, professor of mechanical engineering at Rutgers College, was graduated from Lehigh University with the class of 1893, and until 1908 was connected with the faculty there as instructor, assistant professor, and professor. In 1908 he accepted the chair of mechanical engineering at Rutgers. He is the author of several well-known and highly regarded engineering treatises.

* * *

J. H. Keenan was graduated in 1922 from the course in naval architecture and marine engineering at the Massachusetts Institute of Technology, and then entered the employ of the General Electric Co., Schenectady, N. Y., where he carried on research and development work relating particularly to steam flow. In December, 1923, he undertook for the company the development of the first set of steam charts and tables to be derived from the American Steam Research Program. These were published in MECHANICAL ENGINEERING for February, 1926. In 1928, under the same auspices, he carried out an extension of this work to cover the critical region, and the results are published in this issue.

Since September, 1928, Mr. Keenan has been on the faculty of Stevens Institute as assistant professor of mechanical engineering, where he is now engaged in instruction and research.

* * *

At the Steam Table Research Session of the A.S.M.E. Annual Meeting in December, 1928, several reports were presented. **Geo. A. Orrok,** who reports on general progress, is chairman of the Steam Table Research Fund Executive Committee and a consulting engineer of New York City. **F. G. Keyes** and **L. B. Smith,** who report on the progress of the work at the Massachusetts Institute of Technology, are connected with the research laboratory of physical chemistry at that institution. **N. S. Osborne, H. F. Stimson, and E. F. Fiock,** who together report on the status of the work at the Bureau of Standards, are all associated with the Bureau, Dr. Osborne being its physicist. **J. H. Keenan,** who contributes to the discussion, is associate professor of mechanical engineering at Stevens Institute of Technology, while **J. Havliček,** who writes from Czechoslovakia, was formerly a professor in the University at Zagreb.

* * *

H. N. Davis, president of the Stevens Institute of Technology, received his degree of A.B. from Brown University in 1901 and his A.M. the following year. He also holds the degrees of A.M. and Ph.D. from Harvard University, where from 1905 to 1927 he served on the faculty as an instructor in physics, assistant professor, and professor of mechanical engineering. He was associated with the United States Bureau of Mines in a consulting capacity from 1921 to 1925, and also with the Franklin Railway Supply Co., 1920–1927, and the Air Reduction Co., 1922–1925. Dr. Davis was called to assume the presidency of Stevens in 1928, and was formally inaugurated on November 23. The address which we publish in this issue was delivered upon that occasion. He is also a contributor to the discussion at the Steam Table Research Session reported in this issue.

* * *

V. P. Dolengo-Kozerovsky, who writes on the development of turbo-locomotives in this issue, received his M.E. degree from the University of Cincinnati in 1928. He now holds the position of engineer with the Cincinnati Grinders, Inc.

* * *

This Month's Cover is peculiarly appropriate, since the leading article by V. E. Clark is on the "Historical Development of the American Airplane," and few planes have made more history than has the one flown at Kitty Hawk, N. C., by the Wright brothers. The original picture was made available to us through the kindness of Prof. J. W. Roe, and bears the inscription, "To my friend Professor Roe, Orville Wright." The picture was taken on December 17, 1903, when Mr. Wright succeeded in keeping the plane he and his brother Wilbur had invented in the air for twelve seconds. It shows him lying on the wing of the frail craft and Wilbur watching the first successful flight of a power-driven heavier-than-air machine with a pilot. The plane flew 120 ft.

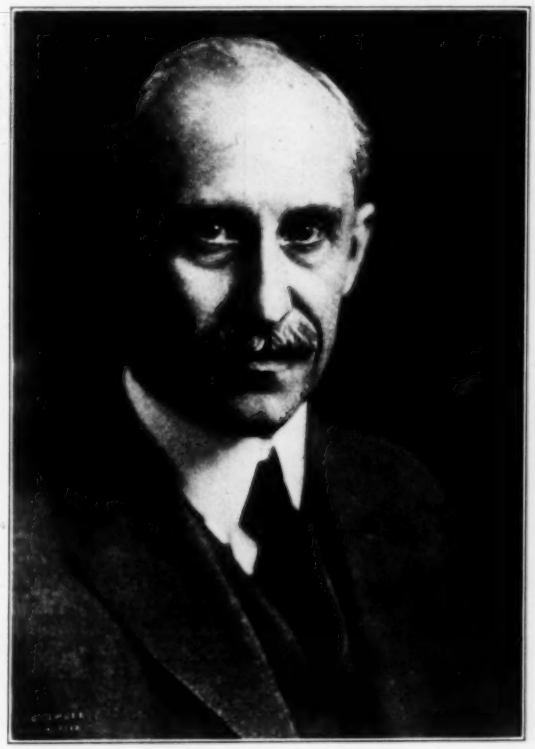
MECHANICAL ENGINEERING

Volume 51 February, 1929 No. 2

Historical Development of the American Airplane

By V. E. CLARK,[1] BUFFALO, N. Y.

AN OUTSTANDING human characteristic is our capacity for forgetting that we have absorbed from others most of the things we think we know. More often than not we fail to appreciate or to remember how much we owe to, and depend upon, the ideas suggested or demonstrated by others. Furthermore the thing we call the courage of our convictions is usually confidence inspired by the knowledge that some one else, through his vision and daring, has already proved a principle which helps us in our development work, but without precedent proof of which we might be skeptical. Progress is progressive. It is difficult if not impossible for the younger generation of today, with pertinent theory developed to some degree at least, and with a wealth of experimental data and of practice in airplane construction to look upon, to picture the barriers which must have surrounded the minds of those interested in heavier-than-air flight in the year 1900 A.D. It is indeed impossible to imagine the outlook in 1800.



ORVILLE WRIGHT

Tangible progress, helpful to those seeking technical knowledge, in the development of man-carrying, power-driven airplanes started less than twenty-two years ago, and we have already sped at the rate of almost five and one-half statute miles a minute, attained altitudes of almost seven and one-half miles, and flown almost forty-five hundred miles without landing. We have seen the airplane become an indispensable weapon in war. We have airplanes carrying mail from San Francisco to New York on a regular 33¾ hour schedule.

And yet, who can say that, fundamentally, the contributions toward development during these twenty-two years have been more important than those prior?

We cannot recite the events making for the development of the airplane in the United States without referring to those pioneers, in thought and deed, of the nineteenth century. History records nothing done before that period. Among others Roger Bacon, John Wilkins, Robert Hooke, and Dr. Johnson had put their fancies of flying machines in writing. Leonardo da Vinci had pondered the problem.

Sir George Cayley and His Followers

But in the notebooks—1809—of Sir George Cayley appear the first crystallized precepts of the importance of the aerodynamic reactions on a *fixed*, rigid airfoil. Newton, thinking of flat plates, had written his "sine-squared" hypothesis which indicated falsely low values for the lift possible on a plate inclined to a relative wind—a lift so small that if his values had been correct, airplane flight would be almost impossible. And yet Newton must have seen, at some time or another, a gust of wind *lift* the roof from his hog pen, and might well have applied his concepts of gravitation, inertia force and acceleration, action and reaction, to see the airplane emerge in his fancy. There is no record of his having done so.

This false "law" of Newton's, then, must have been one of the many barriers which confronted Cayley. Cayley built a whirling arm upon which he mounted bodies of various forms in order to measure aerodynamic reactions. He built and flew models having fixed airfoils and driven helical propellers. Envisioning the structural advantages of the multiplane, he developed streamline sections, for struts and, more important, conceived and developed the basic advantages of airfoil camber. From his tests and computations he came to believe firmly that "the inclined plane, with horizontal propelling apparatus, is the true principle of aerial navigation by mechanical means." He realized that engine power is necessary and that this engine must be lighter in weight than any possible to build following any principle then known; and not only suggested, but tried to build, an engine in which "transfer of energy is brought about by exploding gas within a cylinder!" We are all, indeed, disciples of this great

[1] 2050 Elmwood Avenue.

Presented at the International Civil Aeronautical Conference, Washington, D. C., December, 1928. Contributed by the A.S.M.E. Aeronautic Division.

pioneer. He saw the problem in its true light and warned Henson, in later years, that "a hundred necks have to be broken before all the sources of accident can be ascertained and guarded against."

In 1840 Peacock demonstrated a man-lifting kite. About 1841 Henson advanced sound ideas, developed from his knowledge of Cayley's work, for support and control. In 1848 his associate, Stringfellow, demonstrated a fairly stable and efficient monoplane

SIR GEORGE CAYLEY

with driven helical propellers, and in 1856 built an improved model having propeller, elevator, rudder, and cambered airfoils with which he conclusively proved their superiority over flat plates. This machine did not, however, have means for preserving lateral balance. About 1867 Wenham built a braced multiplane model and also showed the aerodynamic advantages of high aspect ratio.

Boulton, about 1868, proposed ailerons for preserving lateral balance, the fundamental principle of which was the same as that of ailerons of today. In 1876 patents were issued to Penaud and Gauchot for their retractable undercarriage, resilient mount, balanced rudder and elevator, tractor multiple engine, and covered fuselage of streamline form.

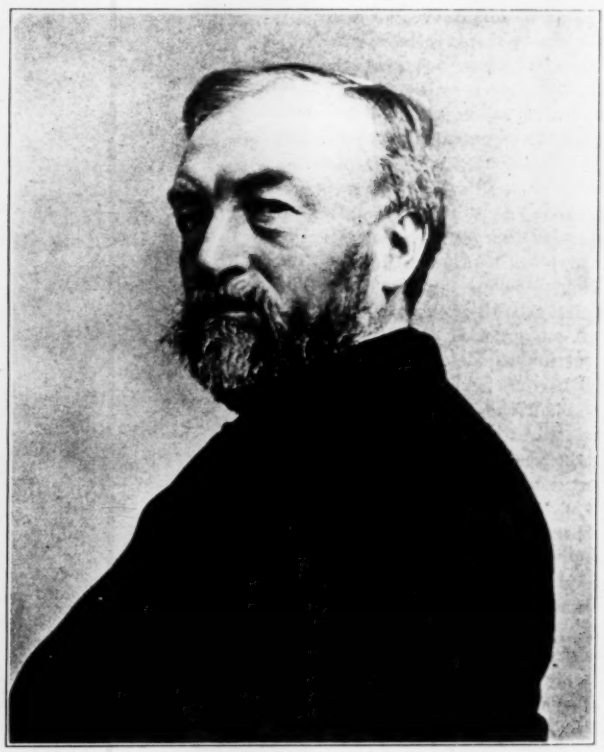
EXPERIMENTS WITH GLIDERS

In 1891 Otto Lilienthal, perhaps the greatest pioneer of all, made his first man-carrying-glider experiments. He had decided that "man must learn to fly," and he himself became the first man to fly. It was not long before he had developed elevators and rudders for his glider, and he must have become remarkably skilful in handling his machine in free flight. Even though Boulton had suggested ailerons, however, Lilienthal did not use any means for preserving lateral balance except shifting his body sidewise. Having proved, through some five hours of free flight, that human flight is possible, he decided to substitute the thrust of a motor-propeller system for the gravity force component to give him the forward speed necessary for support, and built a carbonic-acid gas engine weighing 90 pounds and developing about $2^1/_2$ horsepower, but, unfortunately, he was killed (1895) before he could test his airplane. We cannot praise too highly the moral and physical courage of the first man to fly. In Lilienthal's gliders were embodied a sufficient number of the essential elements for support, stability, and control to afford a successful airplane, had he had a proper power plant. Speed of advance through the air is necessary, but engine power is, in a way, artificial, and has nothing to do with the fundamentals of support, stability, and control. When Lilienthal flew successfully he surmounted the one huge barrier which had terrorized his predecessors.

Two of Lilienthal's students carried the work forward. Pilcher built a glider which was launched from a catapult, and a glider with wheels and shock absorber. He also built a four-horsepower engine, but he, too, was killed (in 1899) before he had an opportunity to test his power-driven airplane. Herring, also a pupil of Lilienthal's, succeeded in interesting Chanute, and these two collaborated in the construction of gliders. They developed a biplane glider (1896) with a very fair interplane structure, and with auxiliary tail surfaces.

EARLY POWER-DRIVEN AIRPLANES

In 1894 Sir Hiram Maxim tested his airplane with two steam engines of approximately one hundred and sixty-five horsepower each. The construction of the airplane itself and of the power plant was quite elaborate. The airplane was a sesquiplane made



SAMUEL PIERPONT LANGLEY (1834–1908)

Secretary of the Smithsonian Institution from 1887 to the time of his death. His investigations in aerial flight, begun in 1889, resulted in the construction of the Langley "Aerodrome," a steam-driven heavier-than-air flying machine, which made its first successful flight (without a pilot) on May 6, 1889. A full-size machine, piloted by the late Charles M. Manly, met with a series of discouraging accidents in launching for attempted flights, and Dr. Langley, his financial support withdrawn, abandoned further trials. On May 28, 1914, after having installed a more modern engine and propeller, and making other alterations, Glenn Curtiss flew the Langley machine at Hammondsport, N. Y.

largely of steel with wooden ribs covered with cotton fabric. It carried one elevator in front and one in the rear, and he intended to provide lateral balance by two side planes set at a pronounced dihedral angle. Steam was developed by a water-tube boiler

with naphtha-vapor burners. Free flight was never attempted, but he succeeded in rising from the ground a matter of three inches with passengers aboard, the total weight of the airplane being some ninety-five hundred pounds. Neither stability nor control was demonstrated. Had he taught himself to fly, as did Lilienthal, perhaps he would have attacked the problem in a different manner.

It has been said that Ader, in 1897, made a short free flight using a steam engine, but this statement is disputed.

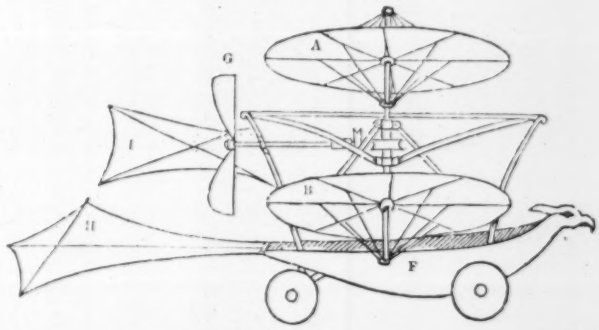
In the same year (1896) that Chanute and Herring were making their glider experiments, Langley, who had done considerable research work in an effort to obtain values of lift, drag, and power required, demonstrated a power-driven model with a thirty-pound steam engine. This model was successful in making flights up to one-half mile in length, and showed a very fair degree of inherent stability. His associate, Manly, later (1902) developed a very fine gasoline airplane engine for which he should be credited.

So it seems that as early as 1896 we had in America sufficient information as to fundamental principles—information resulting from the work of Langley and Chanute combined—to provide a man-carrying, power-driven airplane if the source of power were sufficiently light in weight.

First Flights in America

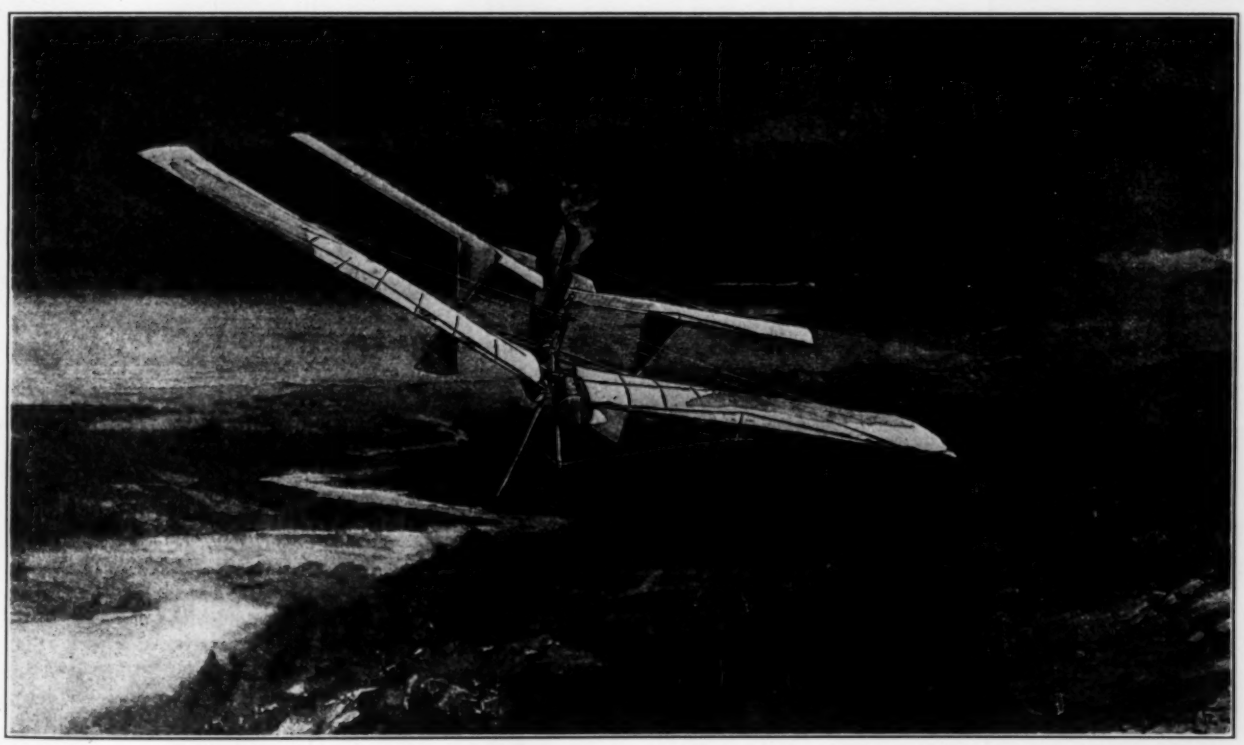
The story of how the Wright brothers, through their courage, sound mechanical instinct, and wisdom in using the wind tunnel, were the first to develop and fly twenty-five years ago a man-carrying, power-driven airplane, has been recounted many times in detail at this Conference. They taught themselves to fly in gliders as had Lilienthal, and did themselves succeed in doing what no one else had accomplished: building and applying a proper engine, with efficient propellers, to their modified and expanded glider.

North Carolina, the scene of their first flights, had bid early for aeronautical fame. In the *North Carolina Gazette*, New Bern, of October 3, 1752, appeared the following:



SIR GEORGE CAYLEY'S AERIAL CARRIAGE

Sir George Cayley, "father of British aeronautics," described his aerial carriage in the *Mechanics' Magazine* for April 8, 1843, in an article in which he criticised a design proposed by Henson in the April 1 issue of the same magazine. The revolving main surfaces *A* and *B* were placed one above the other on each side of the car *F* and were driven from an engine in the car. They were set so that the plane of their surfaces, which had an area of about 100 sq. ft. each, made an obtuse V, and their axes were only 8 ft. from the center of the car. The framing was adapted to increase the stationary wing surface by a covering of canvas, providing a "very flat roof, to keep off rain, etc.," and adding about 130 sq. ft. of surface. Ascent and descent were to be controlled by the horizontal rudder *H*, while the vertical rudder *I* was "for the purpose of lateral steerage in combination with the two propellers which, by being used singly, will turn the machine with great power, and if one be reversed. . . . , a still greater lateral guidance can be obtained."



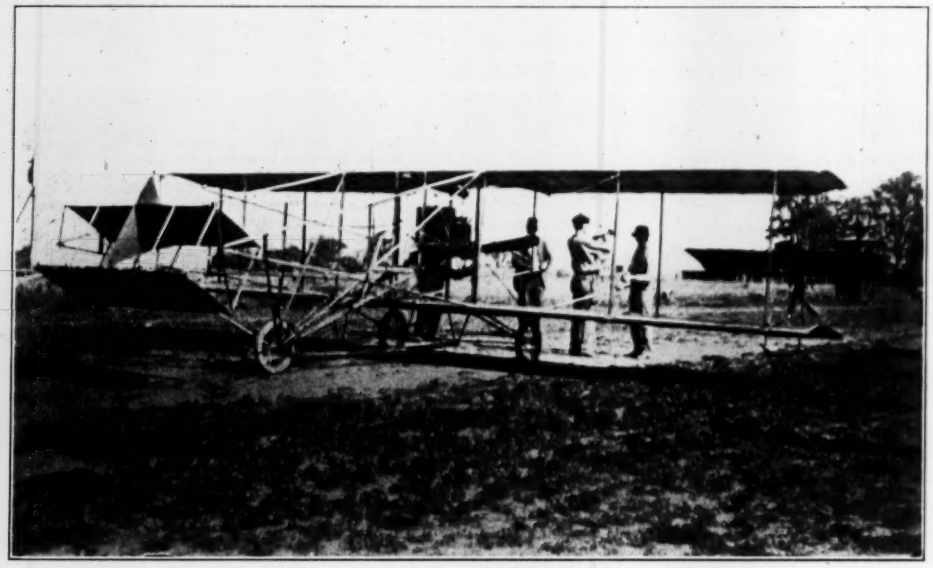
THE LANGLEY AERODROME

Its first successful test over the Potomac River, 30 miles below Washington, on May 6, 1896, was witnessed by Prof. A. Graham Bell, who described it as follows: "On the occasion referred to the aerodrome at a given signal started from a platform about 20 feet above the water and rose at first directly in the face of the wind, moving at all times with remarkable steadiness, and subsequently swinging around in large curves of perhaps a hundred yards in diameter and continually ascending until its steam was exhausted, when, at a lapse of about a minute and a half and at a height which I judged to be between 80 and 100 feet in the air, the wheels ceased turning and the machine, deprived of the aid of its propellers, to my surprise did not fall, but settled down so softly and gently that it touched the water without the least shock, and was in fact immediately ready for another trial."

There is lately arrived in Town from the East Indies, but last from Lisbon, a Man of the most surprising unaccountable Genius, that has appeared in the World for these many Ages past; he says he is an Italian and a Native of Civita Vecchia, named Signore Andreo Grimalde Voltante, aged about Fifty, of a middle Stature, in Holy Orders of the College of Jesus, and went abroad twenty years since to travel in the Eastern Nations, by Order of the Father Provincial of the Propoganda fide. This wonderful Man, after fourteen Years great Labour and Expense, has completed one of the most astounding and compleatest Pieces of Mechanism the World has yet beheld. *It* is a Case of a most curious Texture and Workmanship which, by the Help of Clockwork, *is made to mount in the Air and proceed with that Rapidity of Force and Swiftness, as to be able to travel at the Rate of seven Leagues an Hour.* It is in the shape of a great Bird, the Extent of whose Wings, from Tip to Tip, is twenty-two Feet; the Body is composed of Pieces of Cork, curiously held together by Joints of Wire, covered with Vellum and Feathers; the Wings of Catgut and Whalebone Springs, and covered with the same, and folds up in three Joints each. In the Body of the Machine is contained thirty wheels of peculiar Make, with two Rollers, or Barrels of Brass, and small Chains, which alternately wind off from each other a counterpoise Weight, and by the Help of six Brass Tubes, that slide in Groves, with partitions in them, and loaded with a certain Quantity of Quicksilver, the Machine is by help of the Artist, kept in due Equilibrium and Balance; and by the Friction of a Steel Wheel, properly tempered, and a large surprizing Magnet, the whole is kept in regular progressive Motion, unless the Temperature of Winds and Weather prevents, for he can no more fly in a Calm than he can in a Storm. This wonderful Machine is guided and directed by a Tail seven Feet long, which is fastened by Leather straps to his Knees and Ankles; and by the expanding of his Legs, either to the Right or Left, he moves the Whole which way he chuses; The Head is also beautifully formed, and represents that of an Eagle's. The upper and lower Bill is made of a curious Arabian Goat's Horn, transparent, and the Eyes of Glass, as natural as the Life, and turn upon an Axis inward, by the Help of two Wires fastened to the lower Beak, which keeps all three in perpetual Motion as long as the Machine flies, (which is but three Hours), and then the Wings gradually closes, and he of course lights gently on his Feet, when he winds up the Clockwork, and sets himself again on the Wing.

It would be interesting to know whether or not this journal adhered as sedulously to the truth in technical aeronautical matters as does the modern American press, and, if so, exactly how we should interpret the verb "is made" in the statement "it is made to mount in the air." Many things are manufactured with the intent of doing things, but often we cannot force them to the intended end.

All Wright machines used the principle of the warping wing for lateral control. The first machines used biplane elevators in front and, not being provided with wheels, were perhaps incapable of leaving the ground under their own power, except when faced into a wind. Otherwise, except for the absence of the fuselage enclosing pilots, etc., the basic principles were much as they are in the orthodox airplane of today. The biplane wings had two continuous spars of wood with wooden former and compression ribs, metal fittings, and fabric covering. The airfoil sections were parabolic. To the rear were mounted two vertical rudders of high aspect ratio. The vertical four-cylinder engine drove, through sprockets and chains, two propellers which, because of their slow speed of rotation, developed remarkably high efficiency. It is probable that the first flights were made with a wing loading of less than two pounds per square foot and a power loading higher than sixty pounds per horsepower.



THE GOLDEN FLYER

In 1909, the Aeronautical Society of America advanced funds to Glenn H. Curtiss to build and fly an airplane at a public demonstration, and on June 6, 1909, Mr. Curtiss flew the "Golden Flyer" at Morris Park, New York, N. Y. This hitherto unpublished photograph by Major Carlos de Zafra was taken on the day the historic flight was made. With an improved machine, equipped with a more powerful motor, Mr. Curtiss won the first Gordon Bennett race at Rheims, France, in August of the same year.

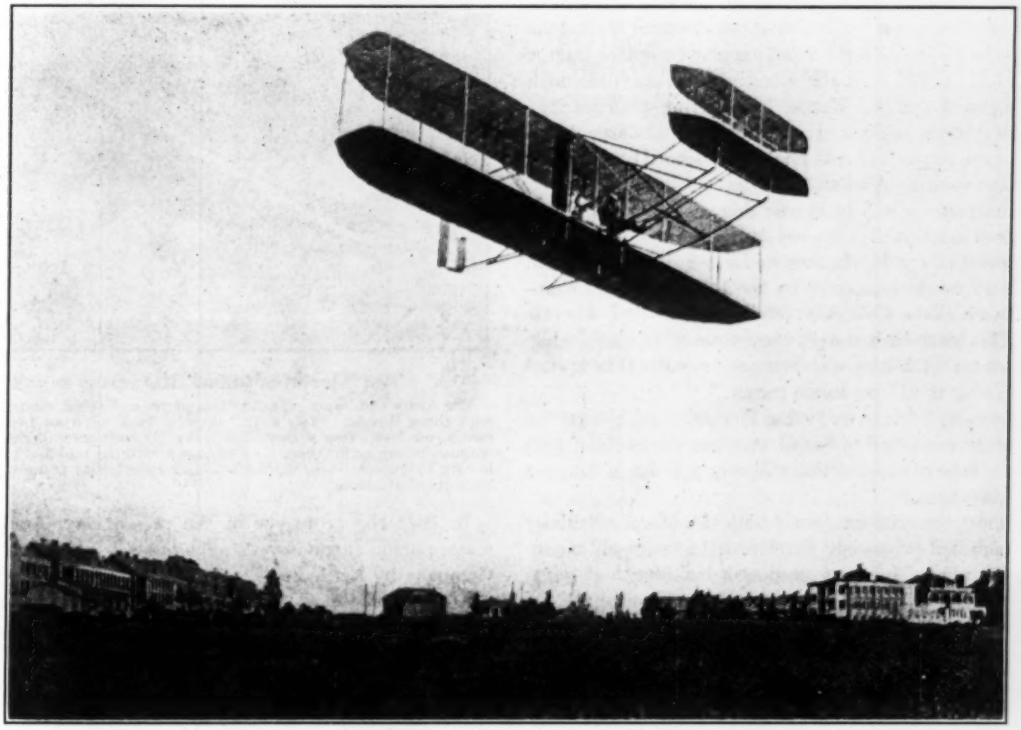
Prior to the year 1908 nothing had been done in America of value toward providing technical information for those who might be interested, although it should be noted, as a daring stunt, that Montgomery (or one of his students) in 1905 succeeded in gliding for twenty minutes after having been dropped from a balloon four thousand feet high. In the meantime, however, Archdeacon, Ferber, Voisin, Blériot, Santos-Dumont, Farman, and others, who had experimented with gliders prior to 1905, had undertaken seriously the construction of airplanes, and in 1906 Santos-Dumont made a public flight of two hundred thirty-eight yards with a power-driven airplane. He had been preceded by a few days by Ellehammer, whose flight, however, did not prove satisfactory control. In 1906 short flights were made in a Blériot monoplane and a Voisin biplane, probably the first airplanes capable of leaving the ground by virtue of their own power, although Santos-Dumont's machine of 1906 may have accomplished this feat—and in 1907 Farman, in a Voisin biplane, and Blériot in his own monoplane, made successful flights which included turns. A. V. Roe, Howard Wright, Barnwell, and others also started developments in 1907.

In 1908 a group of men including Alexander Graham Bell, who had previously constructed tetrahedral kites which were light, strong, and stable, Glenn Curtiss, who had done noteworthy work in the development of light gasoline engines, Lieutenant Selfridge, U. S. Army, F. W. Baldwin, and McCurdy, had built a biplane with ailerons, for which Lieutenant Selfridge is credited with the design. This machine, the "Red-Wing," was flown that year by F. W. Baldwin. The next Curtiss machine, the "White-Wing," designed by Baldwin, used, for the first time in America, a wheel undercarriage. The early Curtiss machines were pusher biplanes built of wood, wire, metal fittings, and fabric covering. On some of these only one surface of the main airfoil was covered.

1909–1915 THE INCUBATION PERIOD

The period of 1909–1915 was for America the real incubation period. Many inventors became interested in aviation, but development was slow and not always forward. Most of the flying was done by "barnstorming," civilian pilots giving flying exhibitions from small race tracks at country fairs. These pilots assembled at rare intervals at aviation meets to compete against each other and against entrants flying Farman, Blériot, or Antoinette machines. Prior to 1914 scarcely any two airplanes were built identical. A few training airplanes were delivered to the Army and Navy by the Wright Company, the Curtiss Company, and by Burgess, who for a time operated under license from the Wright Company, and later built, under license from the English Dunne Company a machine having no tail in which stability was obtained through the washed-out, strong sweep-back wing principle. Exhibition fliers built their own machines or purchased from one of these three companies or from Partridge, Day, or others. In the construction of practically all of these airplanes spruce and ash were used for almost all structural members, which latter were trussed together by wires and steel fittings. Bamboo was used by Curtiss in his early machines for tail booms. Although elevators were, at an early stage, moved from front to rear, most machines of this period were pushers. Day, in 1912, produced a successful tractor biplane having wheel brakes. A few months later the Thomas Company completed another tractor biplane, and in 1913 the Curtiss Company followed. James V. Martin also designed a tractor.

In 1914 appeared two training airplanes which, from the standpoint of agreeable flying qualities, have not been improved upon in America for this type and power. These were the Glenn Martin TT, originally designed by Day in 1913 and developed by Willard, who had been the first student pilot under Curtiss; and the Curtiss J, designed by Douglas Thomas and Henry Kleckler. Both were tractor biplanes with covered fuselages and interconnected ailerons, the Martin having interplane ailerons and the Curtiss having them at the trailing edge. The Curtiss OX, 90-horsepower eight-cylinder engine was used on both.



WRIGHT BROTHERS' AIRPLANE, FORT MYER, VA., SEPT. 9, 1908

At the 1908 annual meeting of the A.S.M.E., George O. Squier, then a major in the Signal Corps of the U. S. Army, presented a paper on "The Present Status of Military Aeronautics," from which this photograph was taken. On Sept. 12, 1908, this machine made a record flight of 1 hour, 14 minutes, and 20 seconds at Fort Myer, Va. The machine attained an estimated maximum speed of about 40 miles per hour. On the cover of this month's issue of MECHANICAL ENGINEERING is a picture of the first flight of a power-driven airplane with pilot made by Orville Wright at Kitty Hawk, N. C., Dec. 17, 1908.

A very creditable development during this early period was that of the seaplane. Following the work of Fabre, who had flown from the water at Martigues, France, in March, 1910, Curtiss, who had been working on the problem since 1909, made a flight in a float seaplane of his own design in 1911, taking off from and landing upon the water successfully. He followed this with the development of the first amphibian, in which, early in 1912, he flew from the water, landed upon the land, took off, landed on the water, and then drove the machine by its own power out on to the shore.

Shortly after the Donnet-Levecque biplane flying boat had flown in France, June, 1912, Loening and Curtiss demonstrated (1912) the first flying boats in America. It is probable that Loening's monoplane flying boat made short hops prior to the

first Donnet-Levecque flights. Benoist had already at this time been doing some experimental work with flying boats in America. Loening's hull was covered with metal, while those of Curtiss and Benoist were of thin wood planking. In 1914 the prototype of the present large flying boats was developed by the Curtiss Company, the *America*, which incidentally was a rival of the early Sikorsky machines in size and load-carrying ability.

It is noteworthy that the Curtiss Company, during this period, built a land-type airplane in which Ely, in January, 1911, alighted upon and flew from the deck of a U. S. cruiser, and also (1913) airplanes of sufficient strength and maneuverability to permit Beachey to perform his thrilling stunts. During the years 1916 and 1917 a number of training airplanes—in the first attempt at standardized production—were delivered to the Army and Navy by the Curtiss Company, the Martin Company, the Standard Company, the Aeromarine Company, the Burgess Company, and the Thomas-Morse Company.

During the winter of 1917–1918 Vought, following the lead of Sopwith with his 1914 one-and-a-half strutter, designed his famous VE-7—the first of his line of refined and popular two-place tractor biplanes. He had, in 1916, built a light and buoyant machine which rivaled the Curtiss J and the Martin TT in flying qualities.

In 1918 the Martin bomber, the first successful large twin-engined, land-type airplane in America, was designed by Douglas, who has given us so many good and practical airplanes.

By this time pushers had been abandoned, except for flying boats, in favor of tractors, but the old "stick-and-wire" construction still remained except for the famous DeH-4 of British design, built for military use in quantities by the Dayton Wright Company, the Fisher Body Company, and the Standard Aircraft Company. This machine had a plywood-covered fuselage, while the "LWF tractor" fuselage was monocoque with thin spruce planking, following the Deperdussin racers.

In 1919, however, Verville, following Fokker's lead, designed a fuselage structure composed of round seamless steel tubing with welded joints, a type of construction still very popular in America but not used elsewhere.

In 1918, almost contemporaneously with the Morane-Saulnier Company, which had previously developed the "parasol" monoplane, and Gourdeau, Loening produced his first high-wing, strut-braced monoplane. The wings were located on top of the fuselage—the arrangement so popular today in American passenger-carrying airplanes. The Morane and Gourdeau machines were parasol monoplanes in which a gap was left between the top of the fuselage and the wing. Loening had, in 1917, already produced a small experimental airplane of this general type.

THE "QUESTION MARK" REFUELING IN THE AIR

The Army endurance refueling test plane, a Fokker monoplane equipped with three Wright "Whirlwind" engines, took off from Los Angeles, California, on New Year's Day and broke all endurance flight records by remaining in the air 150 hours. Compared with the first flight at Kitty Hawk, lasting 12 seconds, this record marks in a spectacular manner the advance of 25 years of aviation.

In 1922 the prototype of the present-day American single-seater pursuit single-bay sesquiplanes was designed for the Boeing Company by Egtvedt.

Today, while most designers use wood and fabric for wings, a few have, following the lead of Breguet, Junkers, Dornier, and others, contributed toward the development of metal structures.

THE LOCKHEED-VEGA "YANKEE-DOODLE"

Compare this modern monoplane with its air-cooled radial "Wasp" engine with the designs of twenty years ago. Piloted by Arthur Goebel, this plane broke the non-stop transcontinental record from the Pacific to the Atlantic Coast, with a flying time of 18 hours and 58 minutes. On a subsequent attempt with another pilot this plane crashed into a mountain side while flying in a fog. Technical advances in aeronautics have not as yet removed this hazard of flying in fog in spite of perfected instruments and the radio.

A Revised Mollier Chart for Steam, Extended to the Critical Point

By J. H. KEENAN,[1] HOBOKEN, N. J.

IN 1925 a steam-table development made at the General Electric Company was presented to The American Society of Mechanical Engineers.[2] It was developed primarily from the Davis-Kleinschmidt Joule-Thomson tests, the first experimental results from the A.S.M.E. Steam Research Program, and extended to 1200 lb. per sq. in. and 800 deg. fahr. Since that time the demand for steam data at still higher pressures and temperatures has been steadily growing. The additional experimental data recently obtained at the Massachusetts Institute of Technology and at the Bureau of Standards have made possible the development of a complete set of steam tables and diagrams to 3500 lb. per sq. in. and 1000 deg. fahr. A year ago the Turbine Engineering Department of the General Electric Company undertook this development. The necessary data and many valuable suggestions were obtained from those engaged in the Steam Research Program, and the successful completion of the work is in no small degree due to their cooperation.

Sources of Data

The Harvard Joule-Thomson-effect experiments which extended to 565 lb. per sq. in. and 657 deg. fahr. had been carefully studied and reformulated by Dr. Davis during 1926 and 1927, and the new formulation was used in this development. It differed only slightly from the older formulation that was used in the work of 1925, but it embodied certain concepts which guided extrapolation.[3]

The Knoblauch specific-heat measurements extending to 420 lb. per sq. in. were used as in the work of 1925 to supplement the Harvard data.[2]

In 1927 Dr. Keyes and Dr. Smith at the Massachusetts Institute of Technology completed a set of experimental determinations of the specific volume of superheated steam between 1350 lb. per sq. in. and 3850 lb. per sq. in., and between saturation and 752 deg. fahr.[3] They constitute the basis of the development between 1000 lb. per sq. in. and 3500 lb. per sq. in.

The same experimenters had determined the pressure-temperature relationship at saturation up to the critical point. These data, which agree closely with the Reichsanstalt experiments, were used in this development.

The Bureau of Standards contributed two very important pieces of data:

1 The mechanical equivalent of heat reported by Dr. Osborne in December, 1927, namely, 1 mean B.t.u. = 778.57 ft-lb.[3] This value was used in the present tables.

2 The total heat of saturated water between 32 deg. fahr. and 482 deg. fahr. (0.09 lb. per sq. in. and 577 lb. per sq. in.), communicated privately with the permission of the Director of the Bureau. Other experimenters contributed minor parts at various stages of the work, but the development was primarily dependent on those mentioned.

Development of the pv/T Chart

The various sources were first used to produce the complete p, v, t relationship shown in Fig. 1.

The Davis Joule-Thomson-effect formulation was integrated to obtain lines of constant total heat, which, with the C_p at zero pressure determined in 1925,[4] gave the variation in total heat over the entire range covered by the formulation. The C_p at zero pressure was not redetermined through the new formulation, because the difference between the old and new formulations was insignificant within the range of the Knoblauch specific heats.

The change in pv/T at constant pressure corresponding to the Davis formulation was then found from the thermodynamic relationship

$$\left[\partial\left(\frac{pv}{T}\right)\Big/\partial t\right]_p = -\frac{p}{T^2}\left(\frac{\partial h}{\partial p}\right)_t \quad \ldots\ldots\ldots\ldots [1]$$

To get the integration constants it was necessary to determine the absolute value of the total heats by fixing on a total heat for saturated steam at atmospheric pressure. The value chosen after a careful consideration of experimental values, the choices of recent investigators, and the values obtained through the Clapeyron relation from the best volume data available was 1150.2 B.t.u. per lb., or a latent heat of 970.2 B.t.u. per lb. (539.0 cal. per gram).

The Davis saturation total heats with the liquid total heats, which will be discussed later, afforded Clapeyron values for volume changes during vaporization, hence saturation volumes. These and the slope in Equation [1] yielded through integration a complete set of volumes and pv/T values.

The Davis formulation volumes, which extended to 1550 lb. per sq. in., were next compared with the Keyes-Smith volumes, which they overlapped slightly. It was found that the Davis values fell lower near saturation and higher at high temperatures than the Keyes-Smith values or their extrapolations. But the Davis saturation line was obviously falling off too rapidly above 1000 lb. per sq. in., which indicated (1) that it was not satisfactory as a basis for integration of the Davis slopes, and (2) that the Davis slopes were too large near saturation at high pressures. The Davis total-heat relationship near saturation at high pressures was found by integrating Joule-Thomson coefficients from zero pressure through a long range of values extrapolated into the supersaturated region. It is obvious that there would be great uncertainty at high pressures concerning all constant-total-heat lines that pass through the supersaturated region, even though the experimental data were correct.

It was necessary, then, to find a more satisfactory basis for the integration of the Davis pv/T slopes. A line of constant temperature for 680 deg. fahr. was carefully constructed passing through the universal gas constant at zero pressure, the Keyes-Smith experimental values above 1600 lb. per sq. in., and the Davis values integrated from Davis saturation at low pressures. In addition it was given a steadily and smoothly increasing slope with pressure. These requirements fixed its position very definitely.

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[1] Assistant Professor of Mechanical Engineering, Stevens Institute of Technology. Formerly of Turbine Engineering Department, General Electric Company. Jun. A.S.M.E.

[2] Mechanical Engineering, February, 1926.

[3] Ibid., February, 1928.

Presented at the Steam Tables Research Session of the Annual Meeting, New York, December 3 to 7, 1928, of The American Society of Mechanical Engineers.

[4] Mechanical Engineering, February, 1926.

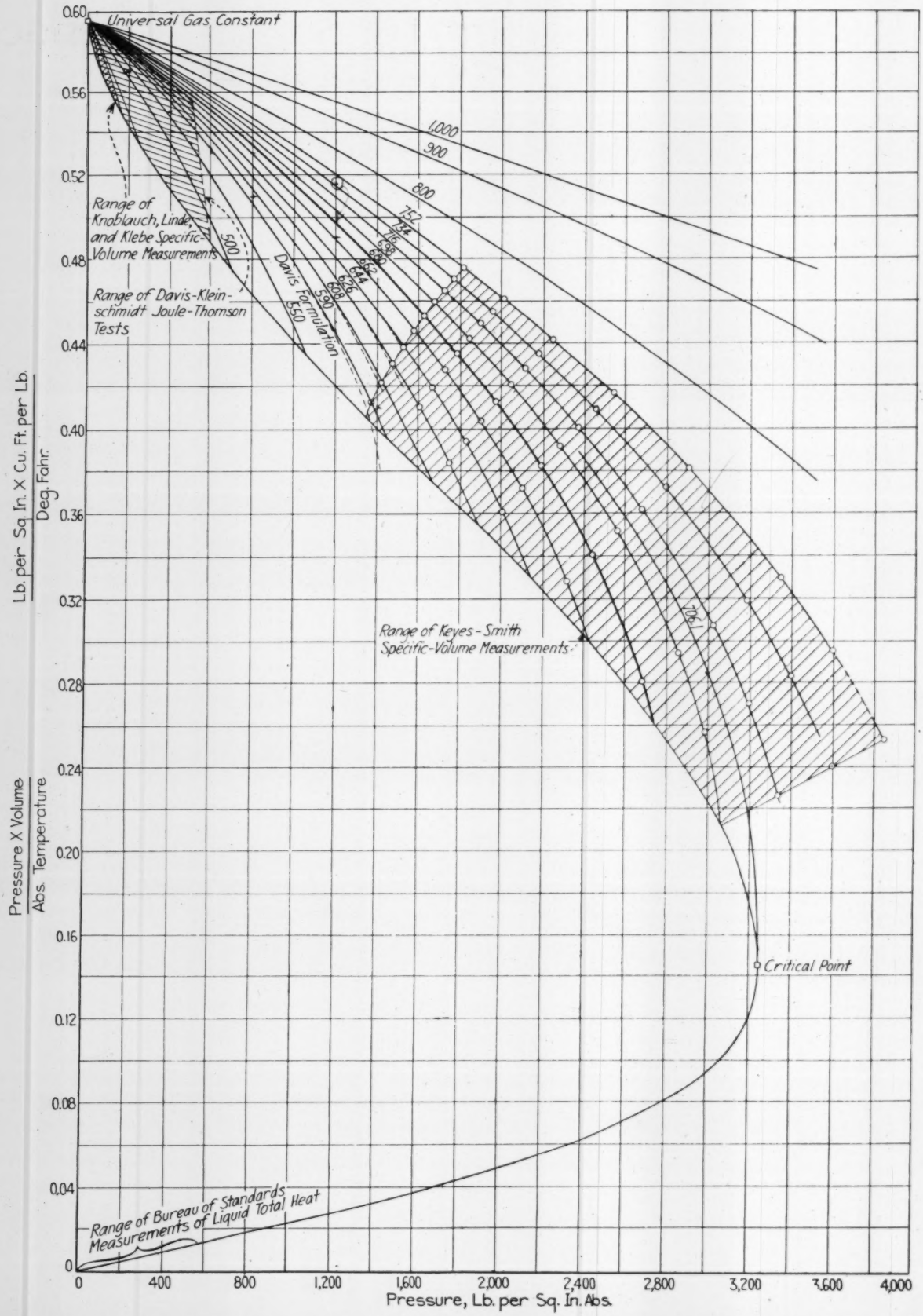

FIG. 1 THE p, v, t RELATIONSHIP. THE REGIONS COVERED BY THE MORE IMPORTANT EXPERIMENTS ARE SHOWN

(The Knoblauch specific heats used extended to 420 lb. per sq. in. Their range is included within the range of the Davis-Kleinschmidt tests. The lines represent the present tables. Figures on curves are temperatures in degrees fahrenheit. The circled points are the Keyes-Smith determinations. The dash lines are the Davis formulation of the Davis-Kleinschmidt tests integrated from the 680-deg. line shown. The remarkably close agreement with the spread of the Keyes-Smith experiments is evident.)

This line was used as the basis for integrating the Davis pv/T slopes, whereupon it was found that between 644 and 752 deg. fahr. perfectly fair constant-temperature lines could be drawn through the Keyes-Smith experiments which practically coincided with the Davis constant-temperature lines to as high a pressure as 1400 lb. per sq. in. Even at temperatures as low as 590 deg. fahr. a fair constant-temperature line coinciding with the Davis line to 1000 lb. per sq. in. would be passed through the Keyes-Smith data (see Fig. 1). This most extraordinary agreement between a formulation of Joule-Thomson tests and an experimental determination of specific volumes is the most striking thing in the entire development.

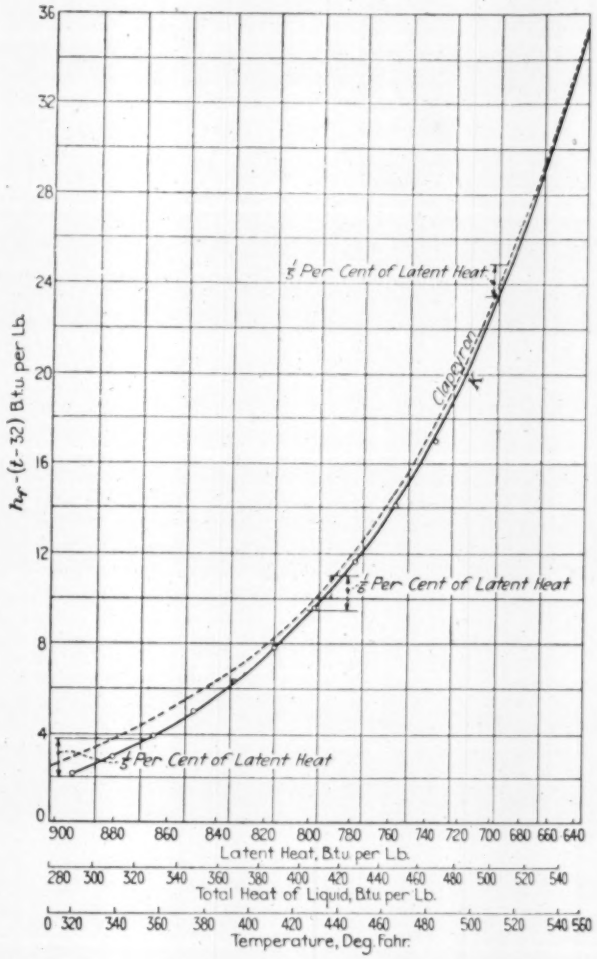
$h_F - (t - 32)$ Btu per Lb.
1/8 Per Cent of Latent Heat
Clapeyron
1/8 Per Cent of Latent Heat
1/8 Per Cent of Latent Heat
Latent Heat, Btu per Lb.
Total Heat of Liquid, Btu per Lb.
Temperature, Deg. Fahr.

FIG. 2 TOTAL HEAT OF SATURATED LIQUID. COMPARISON OF BUREAU OF STANDARDS EXPERIMENTAL DATA AND CLAPEYRON-RELATION VALUES WITH PRESENT STEAM TABLE (K)

(Showing on a large scale the thermodynamic consistency of the table and its agreement with experiment. The excess of the temperature above 32 deg. fahr. has been subtracted from the total heat of the liquid to reduce its range. Circled points are Bureau of Standards experimental values.)

The saturation line above 1300 lb. per sq. in. could be closely determined by a simple extrapolation of the Keyes-Smith volumes. Below 250 lb. per sq. in. the Davis saturation values from the Clapeyron relationship were dependable. Between 750 lb. per sq. in. and 1300 lb. per sq. in. a fair curve was found which gave agreement through the Clapeyron relation with the Bureau of Standards liquid total heats throughout their range (0.1 to 577 lb. per sq. in.) well within the accuracy of our knowledge of $(\partial p/\partial t)_{sat}$ (see Fig. 2). To determine the agreement, it was necessary to integrate total-heat slopes found from the chart through Equation [1] from zero pressure to saturation.

The extrapolation of pv/T to 1000 deg. fahr. was guided by the Davis formulation and a graphic extrapolation of the Keyes-Smith data. The maximum difference between the final 1000 deg. fahr. line and either of these extrapolations was $^3/_4$ per cent.

The critical point was found by the usual extrapolation of the "rectilinear diameter" of the saturation curves on the temperature-density plane. The placing of the saturated-liquid line was guided by the experiments of Ramsey and Young,[5] Waterston,[6] and Hirn.[7]

CALCULATION OF TOTAL HEATS, ENTROPIES, AND SPECIFIC VOLUMES

The p, v, t relationship of the pv/T chart was the basis for all specific volumes, total heats, and entropies in the present tables and charts. The total heats were obtained through Equation [1], integrating from zero pressure and using an atmospheric saturation total heat of 1150.2 B.t.u. per lb. as the basic constant of integration.

A similar basic constant of integration was needed for the calculation of entropies. All entropies at atmospheric pressure were found by integrating

$$ds = \frac{dh}{T} - \frac{v}{T}\,dp \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

from 32 deg. fahr. saturated liquid to the highest temperature tabulated, integrating first along the saturated-liquid line to atmospheric pressure and then at constant pressure. All entropies for superheated steam at other pressures were found by a constant-temperature integration from atmospheric pressure

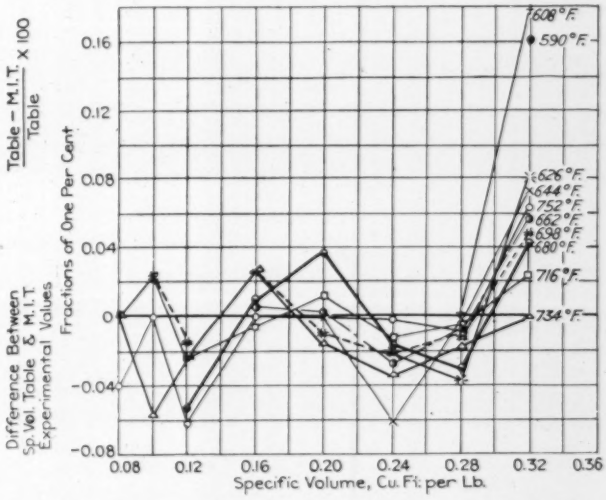

FIG. 3 DEPARTURE OF STEAM-TABLE DEVELOPMENT FROM M.I.T. EXPERIMENTAL VALUES

(Lines connect points of equal temperature.)

of Equation [2], which in terms of ordinates and slopes from the pv/T chart is

$$ds = \left\{ -\frac{T^2}{p}\left[\partial\left(\frac{pv}{T}\right)\Big/\partial t\right]_p - \frac{1}{p}\left(\frac{pv}{T}\right)\right\} dp$$

Latent heats were obtained below 550 lb. per sq. in. from the saturation total heats of the constant-temperature integration

[5] Ramsey and Young, Phil. Trans., vol. 183 (1892), p. 108.
[6] J. J. Waterston, *Phil. Mag.*, vol. 26 (1863), no. 4, p. 116.
[7] G. A. Hirn, *Annales de Chimie*, vol. 10 (1866), no. 4, p. 32.

and the Bureau of Standards liquid total heats. At higher pressures they were obtained from the Clapeyron relation (see Fig. 2).

Liquid entropies were obtained by subtracting the entropy of vaporization corresponding to the latent heat from the saturation entropies found from the constant-temperature integration.

AGREEMENT OF NEW TABLES WITH SOURCES

The departure of the present table from the Keyes-Smith experiments is shown in Fig. 3. It should be noticed that the maximum departure is less than $^1/_5$ of one per cent, and that, excepting the largest volume measurements, which, according to Dr. Keyes, have the largest probable error, no departure exceeds $^1/_{16}$ of one per cent. A comparison at 590 deg. fahr. and 750 deg. fahr. of the experimental values with various steam tables is shown in Fig. 4.

The agreement of the new tables with the Davis-Kleinschmidt Joule-Thomson tests is best shown by comparing temperatures along constant-total-heat lines (Fig. 5). In Fig. 6 the same lines are compared with similar lines from other steam tables.

The agreement between the Bureau of Standards liquid total heats and the new table is shown in Fig. 2. The maximum difference occurs at the highest pressure determination, and is about one part in 2000.

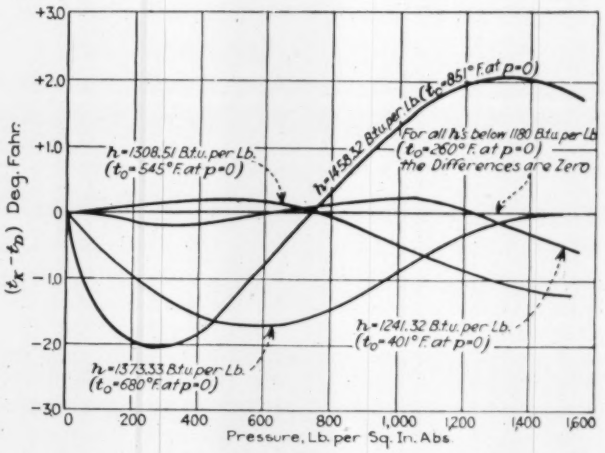
+3.0
+2.0
+1.0
0
−1.0
−2.0
−3.0
$(t_K - t_D)$ Deg. Fahr.
0
200
400
600
800
1,000
1,200
1,400
1,600
Pressure, Lb. per Sq. In. Abs.
h = 1308.51 B.t.u. per Lb. (t_0 = 545° F. at p = 0)
h = 1458.42 B.t.u. per Lb. (t_0 = 851° F. at p = 0)
For all hs below 1180 B.t.u. per Lb (t_0 = 260° F. at p = 0) the Differences are Zero
h = 1241.32 B.t.u. per Lb. (t_0 = 401° F. at p = 0)
h = 1373.33 B.t.u. per Lb. (t_0 = 680° F. at p = 0)

FIG. 5 TEMPERATURE DIFFERENCES BETWEEN CONSTANT-TOTAL-HEAT LINES FROM THE PRESENT TABLE AND LINES FROM THE DAVIS FORMULATION OF THE HARVARD JOULE-THOMSON MEASUREMENTS

(Differences are zero for all total heats less than 1180 B.t.u. per lb. For comparisons with other steam tables, see Fig. 6. t_K is temperature from present table; t_D is temperature from Davis formulation.)

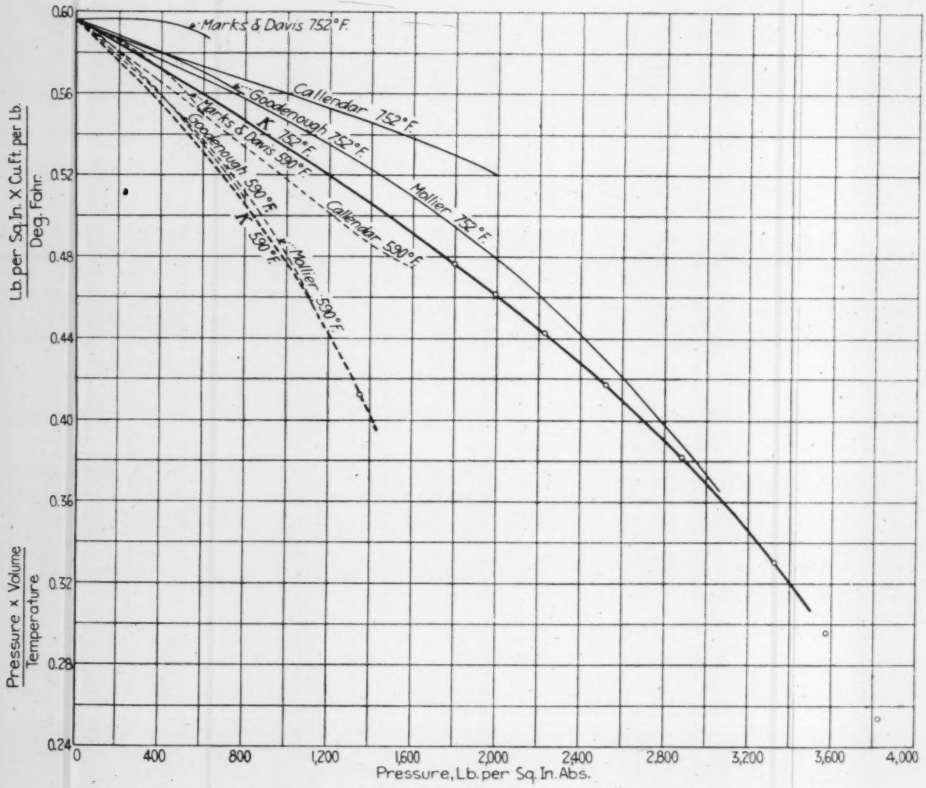

FIG. 4 VOLUME COMPARISON AT CONSTANT TEMPERATURE

(Circles are Keyes-Smith specific-volume determinations. Curves taken from present table are marked "K.")

The present table agrees within $^1/_3$ of one per cent with the recent Jakob latent-heat determinations.[8]

THERMODYNAMIC CONSISTENCY

There are three very severe tests of the thermodynamic consistency of a steam-table development: namely,

1 The Clapeyron check
2 The agreement between the entropy of the liquid as found by subtraction and as found by integration along the saturated liquid line, and
3 The agreement between the variation of entropy at constant pressure as determined by constant-temperature integration and as determined by constant-pressure integration.

The Clapeyron check is difficult to calculate to a high degree of accuracy because of the uncertainty in our knowledge of the first derivative of the pressure-temperature relationship at saturation. A smoothed curve of Clapeyron latent heats checks the table values well within $^1/_{10}$ of one per cent, which is less than the probable error in our knowledge of the pressure-temperature derivatives. (Fig. 2.)

The differences between the entropy of the liquid found by subtraction and that found by integration of $[dh_f/T - (v/T)dp]$ along the saturation line were as follows:

Deg. fahr....	220	300	350	400
Difference...	+0.00006	+0.00016	+0.00022	+0.00032

The discrepancy is one part in 2000 at 400 deg. fahr.

The agreement between the variation in entropy at constant pressure as determined by constant-pressure calculation and by constant-temperature calculation was well within 0.0001 every-

[8] *Z.V.D.I.*, vol. 71, no. 21, p. 720.

TABLE 1 SPECIFIC VOLUMES OF SATURATED AND SUPERHEATED STEAM, CU. FT. PER LB.

Pressure, lb. per sq. in. abs., p	Saturation temperature, deg. fahr.	Superheat, deg. fahr. 0°	10°	20°	30°	40°	50°	60°	80°	100°	120°	140°	160°	180°	200°	300°	400°	500°		Temperature 1000 deg. fahr.
1	101.76	334.0	339.9	345.9	351.8	357.8	363.7	369.7	381.6	393.5	405.5	417.5	429.4	441.3	453.3	513.0	572.5	632.2	....	869.4
2	126.10	174.1	177.1	180.0	183.0	186.0	188.9	191.9	197.9	203.9	209.8	215.8	221.8	227.8	233.8	263.7	293.5	323.3	....	434.7
3	141.49	118.9	120.9	122.9	124.9	126.9	128.9	130.9	134.9	138.9	142.9	146.9	150.9	154.9	158.9	178.8	198.7	218.6	....	289.7
4	152.99	90.79	92.30	93.82	95.30	96.78	98.27	99.77	102.8	105.8	108.8	111.8	114.8	117.8	120.8	135.8	150.7	165.6	....	217.2
5	162.25	73.63	74.84	76.04	77.25	78.46	79.66	80.87	83.28	85.69	88.08	90.48	92.87	95.26	97.66	109.6	121.6	133.6	....	173.8
6	170.07	62.09	63.09	64.09	65.09	66.10	67.11	68.12	70.12	72.15	74.17	76.16	78.16	80.18	82.16	92.13	102.1	112.1	....	144.8
7	176.85	53.74	54.61	55.47	56.32	57.18	58.05	58.92	60.64	62.37	64.10	65.84	67.54	69.26	70.97	79.52	88.09	96.65	....	124.2
8	182.87	47.42	48.17	48.93	49.69	50.44	51.20	51.96	53.48	54.99	56.51	58.01	59.51	61.02	62.52	70.02	77.51	84.99	....	108.6
9	188.28	42.46	43.14	43.81	44.48	45.17	45.84	46.51	47.87	49.21	50.55	51.90	53.24	54.58	55.93	62.58	69.25	75.90	....	96.54
10	193.21	38.47	39.07	39.68	40.29	40.91	41.52	42.12	43.34	44.57	45.75	46.98	48.19	49.40	50.62	56.61	62.61	68.59	....	86.89
15	213.03	26.32	26.73	27.15	27.56	27.97	28.39	28.80	29.62	30.44	31.24	32.06	32.87	33.67	34.48	38.50	42.51	46.50	....	57.92
20	227.96	20.11	20.42	20.73	21.05	21.36	21.67	21.98	22.60	23.22	23.82	24.45	25.05	25.66	26.27	29.29	32.30	35.30	....	43.42
25	240.07	16.31	16.56	16.82	17.08	17.32	17.59	17.84	18.33	18.82	19.31	19.81	20.30	20.79	21.27	23.69	26.12	28.52	....	34.72
30	250.34	13.75	13.97	14.18	14.39	14.61	14.83	15.03	15.45	15.87	16.28	16.68	17.10	17.51	17.92	19.94	21.96	23.96	....	28.93
35	259.28	11.91	12.09	12.27	12.46	12.64	12.83	13.01	13.37	13.72	14.08	14.43	14.78	15.14	15.48	17.23	18.95	20.67	....	24.80
40	267.24	10.50	10.67	10.83	11.00	11.16	11.32	11.48	11.80	12.11	12.42	12.73	13.05	13.35	13.65	15.19	16.70	18.21	....	21.69
45	274.46	9.404	9.550	9.698	9.841	9.986	10.13	10.28	10.56	10.84	11.12	11.40	11.67	11.95	12.22	13.59	14.94	16.28	....	19.28
50	281.01	8.517	8.651	8.784	8.916	9.048	9.179	9.309	9.568	9.819	10.07	10.32	10.57	10.82	11.07	12.29	13.51	14.71	....	17.34
55	287.07	7.788	7.912	8.034	8.155	8.276	8.395	8.514	8.746	8.975	9.204	9.434	9.665	9.897	10.12	11.23	12.34	13.44	....	15.76
60	292.71	7.172	7.286	7.401	7.514	7.626	7.737	7.848	8.061	8.274	8.486	8.696	8.906	9.114	9.322	10.35	11.37	12.37	....	14.44
65	297.97	6.650	6.756	6.862	6.968	7.072	7.177	7.278	7.476	7.673	7.870	8.065	8.258	8.451	8.642	9.590	10.53	11.46	....	13.32
70	302.92	6.203	6.302	6.401	6.499	6.598	6.695	6.791	6.976	7.159	7.343	7.524	7.703	7.883	8.062	8.944	9.818	10.68	....	12.37
75	307.60	5.812	5.906	5.999	6.092	6.184	6.274	6.364	6.538	6.710	6.880	7.051	7.221	7.388	7.556	8.378	9.198	10.00	....	11.54
80	312.03	5.470	5.558	5.645	5.734	5.821	5.906	5.989	6.152	6.315	6.475	6.636	6.796	6.953	7.111	7.883	8.649	9.407	....	10.82
85	316.25	5.163	5.246	5.329	5.412	5.495	5.576	5.654	5.808	5.963	6.115	6.266	6.416	6.565	6.712	7.441	8.164	8.876	....	10.18
90	320.27	4.892	4.972	5.052	5.131	5.210	5.286	5.359	5.505	5.652	5.796	5.942	6.081	6.223	6.362	7.054	7.737	8.409	....	9.610
95	324.13	4.649	4.726	4.804	4.881	4.955	5.026	5.096	5.234	5.374	5.510	5.646	5.782	5.916	6.050	6.705	7.352	7.991	....	9.105
100	327.83	4.426	4.502	4.577	4.649	4.720	4.789	4.855	4.986	5.119	5.249	5.377	5.508	5.636	5.762	6.387	7.001	7.609	....	8.644
110	334.79	4.044	4.114	4.182	4.248	4.313	4.377	4.438	4.558	4.680	4.797	4.916	5.035	5.152	5.266	5.836	6.396	6.950	....	7.853
120	341.26	3.724	3.788	3.852	3.912	3.972	4.031	4.088	4.199	4.312	4.420	4.529	4.638	4.746	4.853	5.376	5.890	6.398	....	7.194
130	347.31	3.451	3.511	3.569	3.626	3.681	3.735	3.788	3.894	3.998	4.099	4.201	4.301	4.401	4.499	4.985	5.460	5.930	....	6.638
140	353.03	3.216	3.270	3.326	3.379	3.430	3.482	3.531	3.630	3.728	3.823	3.917	4.011	4.105	4.196	4.648	5.091	5.526	....	6.161
150	358.43	3.010	3.061	3.113	3.164	3.212	3.260	3.308	3.401	3.493	3.582	3.670	3.759	3.846	3.932	4.355	4.769	5.176	....	5.747
160	363.54	2.830	2.880	2.928	2.975	3.020	3.067	3.110	3.200	3.286	3.369	3.454	3.536	3.618	3.700	4.097	4.487	4.868	....	5.385
170	368.42	2.671	2.717	2.764	2.808	2.852	2.895	2.938	3.022	3.102	3.182	3.261	3.341	3.417	3.493	3.869	4.236	4.596	....	5.065
180	373.08	2.529	2.573	2.617	2.659	2.701	2.742	2.783	2.862	2.939	3.014	3.090	3.165	3.238	3.310	3.665	4.012	4.354	....	4.782
190	377.55	2.401	2.443	2.485	2.525	2.566	2.604	2.643	2.718	2.792	2.865	2.936	3.006	3.077	3.146	3.483	3.813	4.136	....	4.528
200	381.82	2.285	2.325	2.366	2.404	2.443	2.480	2.517	2.589	2.660	2.729	2.797	2.864	2.932	2.997	3.319	3.632	3.940	....	4.299
250	400.97	1.841	1.876	1.909	1.942	1.973	2.003	2.034	2.094	2.152	2.208	2.263	2.319	2.373	2.427	2.688	2.940	3.188	....	3.430
300	417.33	1.542	1.570	1.599	1.627	1.654	1.681	1.707	1.758	1.807	1.856	1.904	1.950	1.996	2.042	2.261	2.474	2.682	....	2.849
350	431.72	1.324	1.350	1.375	1.400	1.425	1.449	1.472	1.516	1.559	1.602	1.643	1.684	1.724	1.762	1.954	2.137	2.315	....	2.436
400	444.58	1.160	1.183	1.206	1.228	1.250	1.271	1.292	1.333	1.372	1.409	1.446	1.482	1.518	1.552	1.722	1.883	2.040	....	2.125
450	456.27	1.030	1.052	1.074	1.094	1.114	1.133	1.152	1.189	1.224	1.259	1.291	1.324	1.356	1.387	1.539	1.684	1.824	....	1.883
500	466.99	0.9261	0.9460	0.9654	0.9845	1.003	1.022	1.039	1.072	1.105	1.136	1.167	1.196	1.225	1.254	1.392	1.523	1.649	....	1.690
550	476.92	0.8402	0.8590	0.8772	0.8950	0.9123	0.9291	0.9455	0.9771	1.007	1.036	1.064	1.091	1.118	1.145	1.271	1.391	1.506	....	1.531
600	486.17	0.7677	0.7855	0.8028	0.8196	0.8359	0.8518	0.8672	0.8966	0.9243	0.9514	0.9778	1.003	1.028	1.053	1.170	1.281	1.386	....	1.406
650	494.89	0.7060	0.7232	0.7397	0.7558	0.7712	0.7860	0.8006	0.8291	0.8554	0.8808	0.9054	0.9293	0.9526	0.9755	1.085	1.188	....	....	1.289
700	503.04	0.6527	0.6692	0.6850	0.7004	0.7153	0.7294	0.7431	0.7692	0.7941	0.8181	0.8412	0.8637	0.8856	0.9070	1.009	1.106	....	....	1.193
750	510.80	0.6063	0.6225	0.6379	0.6526	0.6666	0.6800	0.6931	0.7180	0.7416	0.7643	0.7862	0.8072	0.8280	0.8483	0.9448	1.035	....	....	1.109
800	518.18	0.5653	0.5812	0.5965	0.6103	0.6238	0.6367	0.6493	0.6730	0.6954	0.7167	0.7374	0.7576	0.7775	0.7967	0.8883	0.9727	....	....	1.038
850	525.21	0.5292	0.5448	0.5594	0.5729	0.5860	0.5983	0.6104	0.6332	0.6545	0.6750	0.6947	0.7138	0.7328	0.7511	0.8380	0.9177	....	....	0.9734
900	531.95	0.4969	0.5122	0.5262	0.5394	0.5520	0.5641	0.5756	0.5973	0.6179	0.6374	0.6564	0.6748	0.6928	0.7103	0.7930	0.8686	....	....	0.9166
950	538.40	0.4680	0.4827	0.4966	0.5094	0.5215	0.5331	0.5444	0.5653	0.5850	0.6038	0.6220	0.6397	0.6570	0.6737	0.7529	0.8243	....	....	0.8656
1000	544.58	0.4419	0.4562	0.4696	0.4821	0.4939	0.5052	0.5160	0.5363	0.5553	0.5735	0.5910	0.6081	0.6244	0.6406	0.7164	0.7843	....	....	0.8199
1100	556.28	0.3960	0.4104	0.4231	0.4349	0.4460	0.4567	0.4668	0.4860	0.5038	0.5209	0.5371	0.5529	0.5684	0.5835	0.6532	0.7155	....	....	0.7408
1200	567.14	0.3582	0.3716	0.3840	0.3954	0.4061	0.4163	0.4258	0.4439	0.4607	0.4770	0.4923	0.5072	0.5217	0.5356	0.6002	0.6573	....	....	0.6704
1300	577.32	0.3259	0.3390	0.3508	0.3619	0.3720	0.3817	0.3910	0.4080	0.4240	0.4392	0.4538	0.4681	0.4817	0.4949	0.5551	0.6078	....	....	0.6190
1400	586.96	0.2983	0.3110	0.3223	0.3330	0.3428	0.3522	0.3609	0.3774	0.3927	0.4071	0.4211	0.4345	0.4475	0.4599	0.5161	0.5652	....	....	0.5713
1500	596.08	0.2741	0.2864	0.2974	0.3078	0.3174	0.3265	0.3348	0.3507	0.3656	0.3794	0.3926	0.4052	0.4175	0.4295	0.4822	....	....	....	0.5298
1600	604.74	0.2528	0.2647	0.2758	0.2857	0.2953	0.3040	0.3121	0.3275	0.3417	0.3550	0.3676	0.3798	0.3916	0.4028	0.4524	....	....	....	0.4935
1700	612.98	0.2338	0.2456	0.2565	0.2666	0.2757	0.2842	0.2922	0.3071	0.3206	0.3333	0.3455	0.3572	0.3684	0.3790	0.4261	....	....	....	0.4615
1800	620.86	0.2167	0.2287	0.2394	0.2492	0.2582	0.2666	0.2744	0.2886	0.3017	0.3140	0.3257	0.3370	0.3476	0.3578	0.4026	....	....	....	0.4330
1900	628.39	0.2014	0.2136	0.2242	0.2338	0.2424	0.2507	0.2583	0.2723	0.2849	0.2968	0.3082	0.3189	0.3291	0.3387	0.3813	....	....	....	0.4075
2000	635.61	0.1875	0.1996	0.2102	0.2196	0.2284	0.2364	0.2438	0.2574	0.2696	0.2813	0.2923	0.3025	0.3123	0.3215	0.3620	....	....	....	0.3846
2100	642.56	0.1744	0.1870	0.1976	0.2071	0.2155	0.2234	0.2307	0.2440	0.2561	0.2672	0.2776	0.2875	0.2968	0.3059	0.3447	....	....	....	0.3639
2200	649.25	0.1623	0.1752	0.1860	0.1955	0.2038	0.2115	0.2188	0.2317	0.2435	0.2541	0.2644	0.2740	0.2830	0.2916	0.3286	....	....	....	0.3452
2300	655.70	0.1509	0.1644	0.1752	0.1847	0.1931	0.2007	0.2077	0.2204	0.2319	0.2425	0.2523	0.2614	0.2702	0.2785	0.3142	....	....	....	0.3280
2400	661.94	0.1404	0.1546	0.1656	0.1750	0.1832	0.1907	0.1977	0.2103	0.2213	0.2316	0.2411	0.2500	0.2585	0.2666	0.3007	....	....	....	0.3122
2500	667.98	0.1304	0.1454	0.1566	0.1660	0.1741	0.1816	0.1884	0.2007	0.2116	0.2216	0.2308	0.2395	0.2477	0.2554	0.2884	....	....	....	0.2976
2600	673.82	0.1205	0.1369	0.1482	0.1575	0.1657	0.1730	0.1797	0.1918	0.2025	0.2122	0.2212	0.2297	0.2376	0.2451	0.2768	....	....	....	0.2842
2700	679.46	0.1110	0.1288	0.1404	0.1498	0.1579	0.1652	0.1719	0.1837	0.1942	0.2036	0.2125	0.2207	0.2283	0.2355	0.2662	....	....	....	0.2719
2800	684.91	0.1022	0.1213	0.1331	0.1426	0.1506	0.1578	0.1644	0.1760	0.1863	0.1956	0.2041	0.2121	0.2196	0.2266	0.2563	....	....	....	0.2604
2900	690.17	0.0932	0.1142	0.1262	0.1357	0.1437	0.1511	0.1575	0.1689	0.1788	0.1881	0.1963	0.2042	0.2114	0.2183	0.2472	....	....	....	0.2498
3000	695.25	0.0843	0.1074	0.1198	0.1294	0.1374	0.1446	0.1510	0.1621	0.1722	0.1810	0.1891	0.1967	0.2037	0.2103	0.2385	....	....	....	0.2397
3100	700.17	0.0744	0.1008	0.1138	0.1236	0.1316	0.1385	0.1448	0.1560	0.1657	0.1744	0.1824	0.1897	0.1965	0.2029	....	....	....	....	0.2302
3200	704.91	0.0608	0.0949	0.1079	0.1177	0.1259	0.1329	0.1390	0.1500	0.1595	0.1681	0.1759	0.1831	0.1897	0.1960	....	....	....	....	0.2216
3226	706.10	0.0522	0.0936	0.1066	0.1163	0.1244	0.1314	0.1375	0.1485	0.1580	0.1665	0.1743	0.1814	0.1880	0.1943	....	....	....	....	0.2193

Pressure, lb. per sq. in. abs., p	Temperature, deg. fahr. 720°	730°	740°	750°	760°	770°	780°	790°	800°	820°	840°	860°	880°	900°	950°	1000°
3300	....	....	....	....	0.0903	0.1033	0.1129	0.1208	0.1277	0.1339	0.1396	0.1447	0.1496	0.1584	0.1663	0.1736	0.1804	0.1866	0.2008	0.2132
3400	....	....	....	....	0.0760	0.0929	0.1039	0.1124	0.1196	0.1260	0.1319	0.1372	0.1421	0.1510	0.1589	0.1662	0.1729	0.1791	0.1932	0.2055
3500	....	....	....	....	....	0.0821	0.0948	0.1042	0.1121	0.1188	0.1246	0.1300	0.1351	0.1440	0.1519	0.1592	0.1659	0.1721	0.1860	0.1982

where in the superheat region with the exception of the immediate neighborhood of the critical point, where first derivatives become so large as to make it difficult to determine the consistency.

This extraordinarily high degree of thermodynamic consistency coupled with close adherence to experimental data shows the advantage of the graphic method of development. The inconsistencies that exist are smaller than the uncertainties in fundamental data and are negligible for even the most exacting type of engineering work. The agreement with the experimental sources is in all cases within the probable experimental error.

CHANGES IN CHARTS AND TABLES OF 1925

Though the present tables embody a complete revision of the tables and charts presented in 1925, very little change has been made in them except in the high-temperature, high-pressure region, where there is a maximum change in total heat of about 3 B.t.u. per lb. Available energies remain very nearly the same, specific volumes are the same within $\frac{1}{2}$ per cent up to 750 lb.

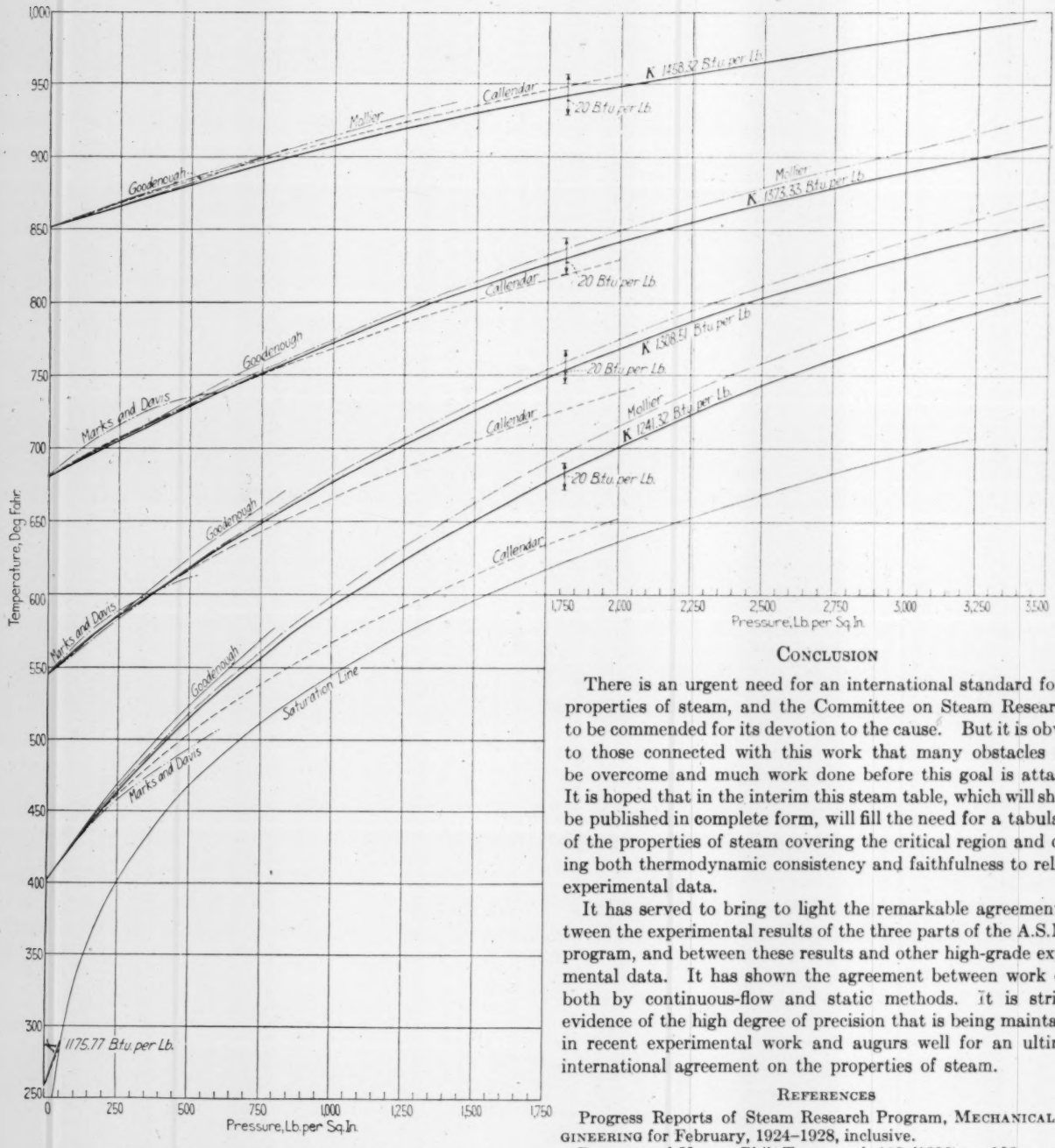

FIG. 6 CONSTANT-TOTAL-HEAT LINES

(Comparison of present tables (K) with Goodenough, Marks & Davis, Mollier, and Callendar tables. Note that 1 B.t.u. per lb. is equivalent to 2 deg. fahr. or less. The differences between the K-curves and the Davis formulation of the Harvard experiments are too small to be shown on this scale. They are plotted to a magnified scale in Fig. 5.)

per sq. in., but are altered as much as $1^1/_2$ per cent at 1200 lb. per sq. in., and some improvements in consistency have been made.

CONCLUSION

There is an urgent need for an international standard for the properties of steam, and the Committee on Steam Research is to be commended for its devotion to the cause. But it is obvious to those connected with this work that many obstacles must be overcome and much work done before this goal is attained. It is hoped that in the interim this steam table, which will shortly be published in complete form, will fill the need for a tabulation of the properties of steam covering the critical region and offering both thermodynamic consistency and faithfulness to reliable experimental data.

It has served to bring to light the remarkable agreement between the experimental results of the three parts of the A.S.M.E. program, and between these results and other high-grade experimental data. It has shown the agreement between work done both by continuous-flow and static methods. It is striking evidence of the high degree of precision that is being maintained in recent experimental work and augurs well for an ultimate international agreement on the properties of steam.

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Total Heat-Entropy Diagram

Developed from Davis-Kleinschmidt Joule-Thomson Tests, Keyes-Smith Specific-Volume Determinations, and Bureau of Standards Liquid Heats.

As reported in brief in "Mechanical Engineering," February, 1928.

(1 B.t.u. = 778.57 ft-lb.)

GENERAL ELECTRIC COMPANY

Absolute pressure, in. Hg	Saturation temperature, deg. fahr.	Absolute pressure, lb. per sq. in.	Saturation temperature, deg. fahr.
1	79.1	220	389.9
1 1/2	91.8	240	397.4
2	101.2	260	404.4
Lb. per sq. in.		280	411.1
		300	417.3
1.5	115.7	350	431.7
2	126.1	400	444.6
3	141.5	450	456.3
4	153.0	500	467.0
5	162.3	550	476.9
6	170.1	600	486.2
7	176.9	650	494.9
8	182.9	700	503.0
9	188.3	750	510.8
10	193.2	800	518.2
12	202.0	850	525.2
14	209.6	900	532.0
16	216.3	950	538.4
18	222.4	1000	544.6
20	228.0	1100	556.3
22	233.1	1200	567.1
24	237.8	1300	577.3
26	242.3	1400	587.0
28	246.4	1500	596.1
30	250.3	1600	604.7
35	259.3	1700	613.0
40	267.2	1800	620.9
45	274.5	1900	628.4
50	281.0	2000	635.6
55	287.1	2100	642.6
60	292.7	2200	649.3
70	302.9	2300	655.7
80	312.0	2400	661.9
90	320.3	2500	668.0
100	327.8	2600	673.8
110	334.8	2700	679.5
120	341.3	2800	684.9
130	347.3	2900	690.2
140	353.0	3000	693.3
150	358.4	3100	700.2
160	363.6	3200	704.9
180	373.1	3226	706.1
200	381.8		

(The above preliminary experimental results were obtained through the courtesy of the experimenters and the A.S.M.E. Committee on Properties of Steam and the Extension of the Steam Tables.)

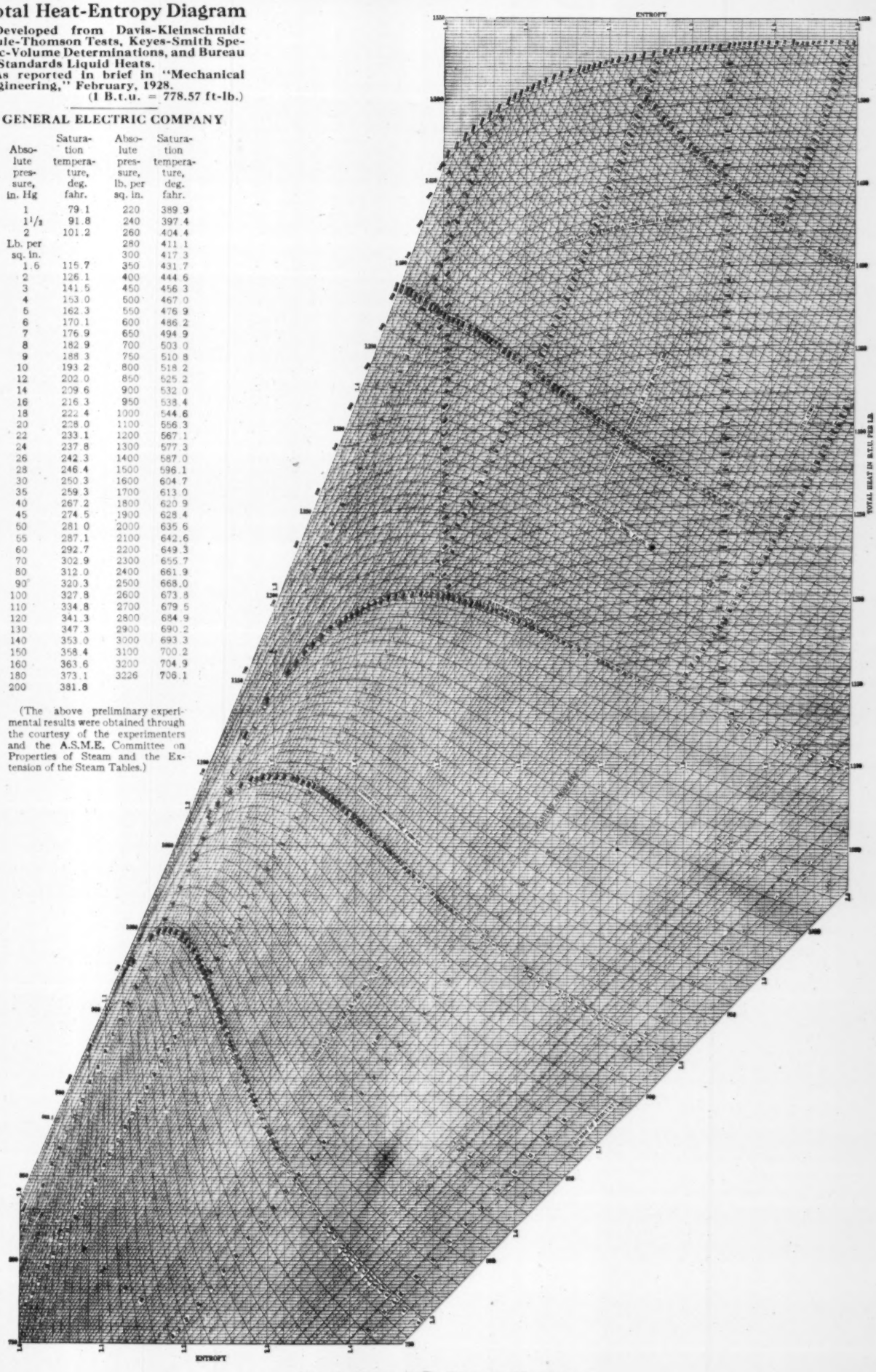

FIG. 7 TOTAL HEAT-ENTROPY DIAGRAM

A General Steam Equation?

By R. C. H. HECK,[1] NEW BRUNSWICK, N. J.

IT IS highly desirable that the properties or coordinates of steam shall, if possible, be formulated and related by correct general equations of unrestricted range. Whether such equations can be established is a part of the big problem of formulating all gaseous substances. The purpose of this paper is to make a showing of the status of that problem, in the form of a graphic exhibit of what can be accomplished with several types of the pressure-volume-temperature equation. The substance chosen for study is CO_2, because of the relatively wide range of measurement of its properties, as consistently laid out in the graphical formulation of his own results by Amagat.

General Form of the Problem

The characteristic equation, or equation of state, relating temperature, pressure, and volume, presents the first and simplest problem. Typical behavior is shown by Figs. 1 to 6, with two systems of plotting. The first uses the simple coordinate p or v as dependent variable; in the second the product pv is plotted on p or on v. Description and explanation are as follows:

The ideal gas is composed of molecules of which the aggregate bulk is infinitesimal in comparison with the space occupied by

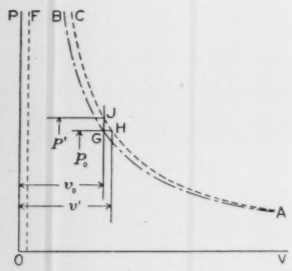

Fig. 1 Ideal and Full Curves

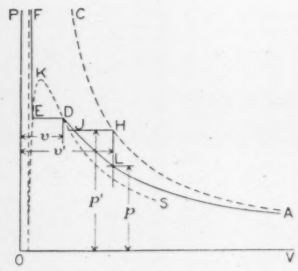

Fig. 2 Full and Actual Curves

Figs. 1 and 2 Plot of Isotherms in the p — v Plane
(Curve $ADEF$ in Fig. 2 is the 20-deg. isotherm from Fig. 10.)

the substance; these molecules are perfectly elastic as they collide and rebound; and among them there are no attractive forces. Such a gas conforms exactly to the equation

$$pv = rT \quad \ldots\ldots [1]$$

as represented by curve or line AB in Figs. 1 and 3.

Actually the molecules have an appreciable aggregate bulk effectively measured by the volume of the liquid at low temperature, which becomes relatively considerable and then predominant as pressure and density rise. Functioning alone, as it does in the case of the relatively very high isotherms of hydrogen in Fig. 8, the presence of molecular volume changes the equation to

$$p(v - b) = rT \quad \ldots\ldots [2]$$

in which the aggregate molecular volume b is commonly called the covolume. This equation is represented by curve or line AC in Figs. 1 to 4.

In Fig. 1 the following dimensions are distinguished:
At a particular pressure p, or at the height of GH

Ideal volume, $v_0 = rT/p$
Full volume, $v' = v_0 + b$

In a particular volume v, or over to GJ

Ideal pressure, $p_0 = rT/v$
Full pressure, $p' = rT/(v - b)$

The word "full" is used in a conventional sense, to mean "unreduced by molecular attractions." It might also be appropriate to call v_0 or p_0 the first ideal value and v' or p' the second ideal value of the particular quantity.

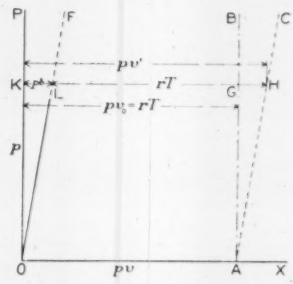

Fig. 3 From Fig. 1

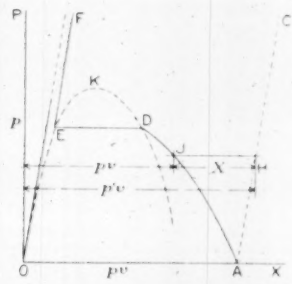

Fig. 4 From Fig. 2

Figs. 3 and 4 The Plot of Product pv on a Vertical Base of p

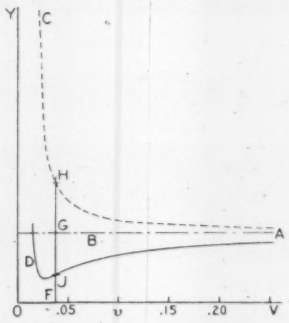

Fig. 5 On Volume v

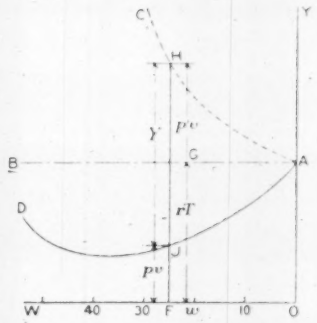

Fig. 6 On Weight w or $1/v$

Figs. 5 and 6 Product pv on Specific Volume v or Specific Weight w
(Curve AJD is the 50-deg. isotherm from Fig. 9 or 10.)

Full curve AC is transferred from Fig. 1 to Fig. 2, then beneath or inside of it appears the actual isotherm $ADEF$, taken below the critical temperature so as to cut across the saturation or mixture region from D to E. Now we have:

Actual volume v less than v' by a contractive effect $(v' - v)$ or x.

Actual pressure p less than p' by a contractive effect $(p' - p)$ or y.

Toward saturation and for the isotherm EF of the liquid these departures from ideal-gas behavior become relatively very large.

A much more manageable and effective type of diagram is obtained by plotting product pv instead of simple v or p. This quantity has but a small range of size variation, hence its whole range of behavior can be shown to large scale in a compact diagram. Whether the base is pressure p or volume v makes a big difference in the form of the diagram. In Figs. 3 and 4,

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[1] Professor, Mechanical Engineering, Rutgers College. Mem. A.S.M.E.

Contributed by the Research Special Committee on Properties of Steam and the Extension of the Steam Tables and presented at the Annual Meeting, New York, N. Y., Dec. 3 to 7, 1928, of The American Society of Mechanical Engineers.

which show pv (horizontal) on p (vertical), the steps from first ideal to second ideal action and from second ideal to real action are separated, as in Figs. 1 and 2. Note the symbol X for the contraction from pv' to pv. Wide-range diagrams in the terms of Fig. 4 appear in Figs. 7 to 10.

A sample plot directly on v of isotherms in pv is given in Fig. 5. Again, straight line AB shows the constant pv from Eq. [1]

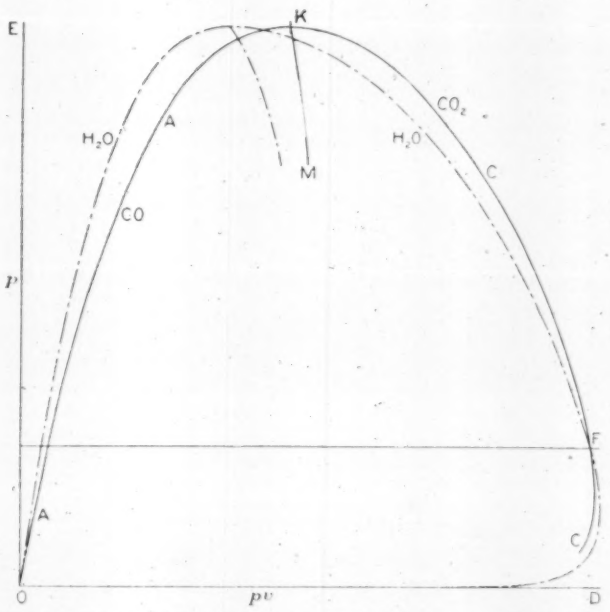

FIG. 7 COMPARATIVE SATURATION BOUNDARY CURVES, STEAM AND CARBON DIOXIDE

and AC is $p'v = rT \times v/(v - b)$ from Eq. [2]. Because the difference between these quantities becomes very large at small volumes, the vertical scale of pv is small. Actual isotherm AJD, now taken above the critical temperature of the substance, shows an abrupt change of trend in the region of small volumes and high densities.

The scheme of Fig. 5 has the fault of spreading out unduly the region of large volumes where behavior is simple, while too much crowding together the small-volume region where behavior is complex and hard to formulate. A big improvement is made by changing to the reciprocal $w = 1/v$ as base, or to the weight per cubic foot of the substance, as in Fig. 6 or Fig. 12. Now the symbol Y stands for $(p'v - pv)$, and the curve AD of real pv has a simpler form than in Fig. 5, probably simpler for formulation, certainly so for the testing of a formula. With $1/w$ in place of v, Eq. [2] becomes

$$p'\left(\frac{1}{w} - b\right) = rT \qquad p' = rT\,\frac{w}{1 - bw}$$

whence

$$p'v = \frac{p'}{w} = \frac{rT}{1 - bw} \quad \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

This gives the ordinates of curve AC in Fig. 6. Because of larger vertical scale (than in Fig. 5) and of the change of base, this curve rises very rapidly as the gas is compressed, suggesting a difficulty in the close formulation of the left-hand end of curve AD. Mathematically, as well as in physical experiment, it is difficult to get closely a small quantity which is the difference of two very large ones.

THE QUESTION OF SIMILARITY

The value of an investigation upon CO_2 when the real interest is in H_2O depends upon the validity of the assumption that different gaseous substances behave in very much the same way. A first test, involving the two substances immediately in question, is made in Fig. 7 by plotting comparatively the boundary curves of the saturated state, or of the region of the liquid-and-vapor mixture. Here the pressures are expressed in terms of the critical pressure p_k as unit, while the horizontal unit is the value of pv at one-fourth of p_k (at point F). The curve for H_2O is from the author's paper,[2] "Steam Formulas" (1920); the CO_2 curve represents the summary by Jenkin and Pye (1914) of all the experimental data.

Further light is thrown upon the question of similarity, as also upon the general behavior of gases, by Fig. 8, where isotherms determined by Amagat for a number of gases are plotted together, with the value of pv at zero centigrade and atmospheric pressure as horizontal unit. This exhibit runs to pressures so high that the product pb really becomes a large quantity. In the exhibit a major variable (as among the various gases) is the relative temperature, for which either the critical temperature T_k or the range temperature of liquefaction might serve as base. Over the covered range from 0 to 200 deg. cent. the following conditions appear:

Hydrogen H_2 is so far from liquefaction that the shrinkage effect due to molecular attractions has practically disappeared; the isotherms are essentially straight lines, conforming to Eq. [2]. At 0 deg. cent. there is just a beginning of the curvature that is an outstanding feature of the isotherms shown for other gases.

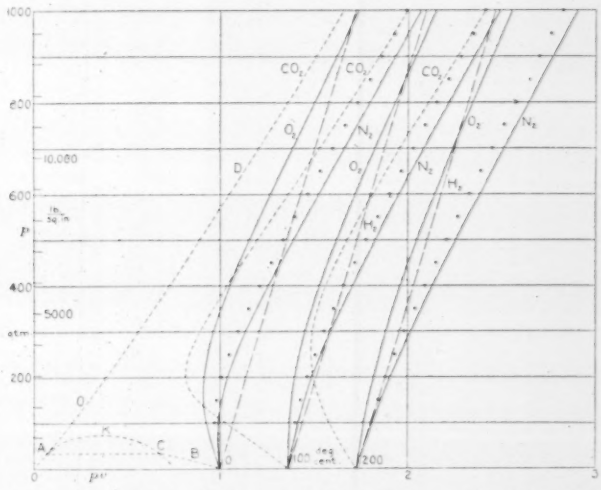

FIG. 8 COMPARATIVE PLOT OF AMAGAT RESULTS, SHOWING HYDROGEN, NITROGEN, OXYGEN, AIR, AND CO_2

Nitrogen N_2 and oxygen O_2 (with their mixture air according to the dot curves) are nearer to liquefaction and show a curvature which increases rapidly as temperature falls. While fairly close together as to relative temperature these two gases show interesting dimensional differences. The evident greater slant of the lines from which the N_2 curves are departing—lines like AC in Fig. 4—indicates that liquid N_2 is lighter than liquid O_2; and the greater curvature and contraction of the O_2 curves is in accord with the fact that the critical temperature of oxygen is considerably higher than that of nitrogen.

Carbon dioxide here runs into and across the region of lique-

[2] Transactions, A.S.M.E., vol. 42 (1920), p. 711.

faction, ranging from the liquid state at 0 deg. to high superheat at 200 deg. Its gas isotherms at 100 and 200 deg. show great but rapidly decreasing curvature.

The proportions of an exhibit like Fig. 8 would be modified if the plot were made with actual or absolute values of ordinate pv, instead of relative values. Whatever the scheme of plotting, the major characteristic difference among the sets of isotherms lies in the magnitude of covolume b; this manifests itself in the slope of the pv' lines (not drawn), which can be inferred from the slope of the upper ends of the isotherms. Allowing for this difference, and with relative temperature as a basis of relationship, the whole set of examples shows successive strips of a similar and consistent type of behavior. As they get up into the temperature range of combustion-engine conditions, the isotherms of even CO_2 and H_2O will lose their contractive component and come to the shape of the hydrogen lines in Fig. 8.

Volume on Temperature and Pressure

The full plot of pv on p for CO_2 is made in Fig. 9, and the more useful part of this diagram is enlarged in Fig. 10, with an isotherm at each 10 deg. cent. These figures show the result published by Amagat in 1893, with interpolations (and extrapolation at the right of Fig. 9). Dotted curve NN in Fig. 9 is the locus of the inversion point, the place where any isotherm is at its minimum of pv and is instantaneously vertical. Note in Fig. 8 how the curves for O_2 and N_2 are just inside of inversion at 0 deg., but have passed beyond it at 100 deg. The inclined

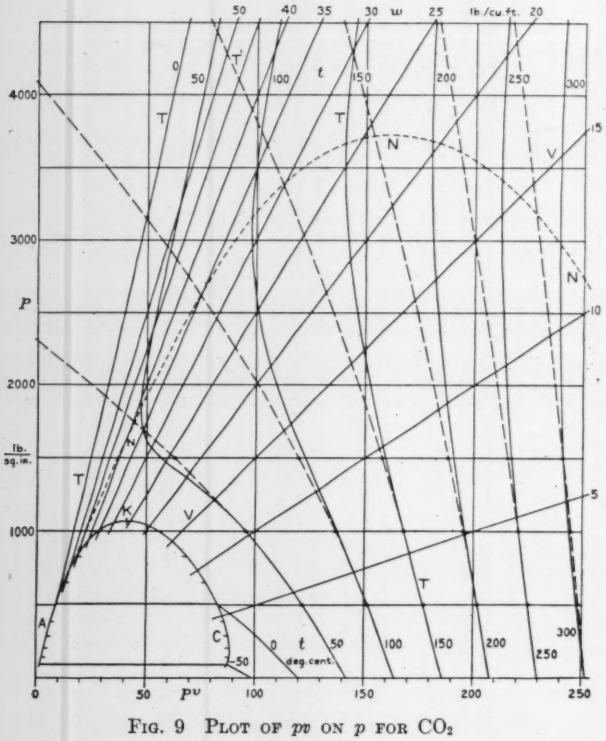

FIG. 9 PLOT OF pv ON p FOR CO_2

straight lines in Fig. 9, radiating from the origin, are lines of constant volume, to be used in laying out Figs. 12 and 13. One of them is lettered VV, but they are designated by the value of w, the weight per cubic foot, equal to $1/v$.

The dotted curves type TT', which run with the plotted isotherms at low pressures, then swing away toward the left, come from an equation of the form

$$pv = rT - X = rT - f(p,T) \quad \ldots\ldots\ldots\ldots [4]$$

This is the type of steam equation first introduced into practical use by Callendar and elaborated by Goodenough and by the writer. With gas constant r determined by the molecular weight of CO_2 and with its four constants (two coefficients and two exponents) fixed by the coordinates of the four circled-dot points in Fig. 10, the definite equation is

$$pv = 0.4392T - \frac{[5.56160]}{T^{2.8}}\,p - \frac{[13.40650]}{T^{7.3}}\,p \quad \ldots\ldots\ldots [5]$$

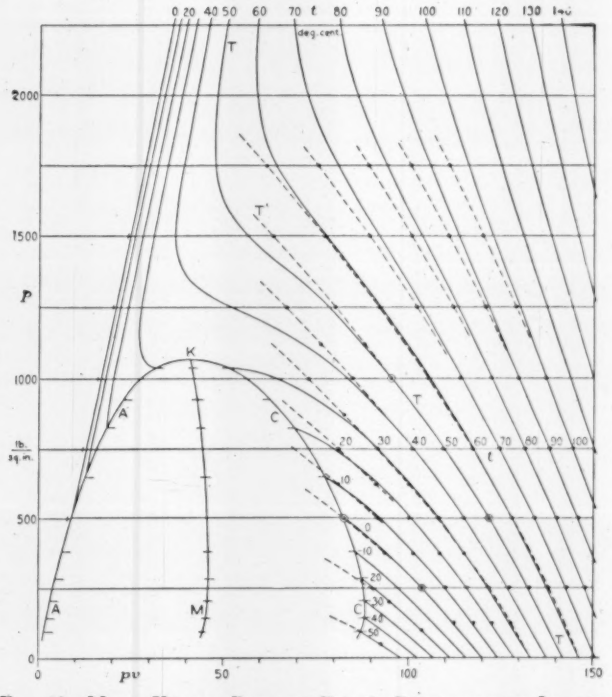

FIG. 10 MORE USEFUL PART OF FIG. 9, REPLOTTED TO LARGER SCALE AND AT CLOSER TEMPERATURE INTERVALS

(The bracketed log in Eq. [5] represents its antilog or the corresponding number.) Here pressure p is in pounds per square inch, volume v in cubic feet per pound, and absolute temperature T in degrees centigrade. With fahrenheit degrees the constant r would change to $0.4392 \div 1.8 = 0.2440$, to be compared with the familiar 0.3702 for air or with 0.5952 for steam.

It is seen from Fig. 9 that this equation is a fair approximation up to about the critical pressure, but wholly fails to represent what happens at very high pressures and densities. In Fig. 10 the comparison is more detailed, showing the excess curvature of the formula isotherms at low pressure (as drawn at 30 and 60 deg.) and their decidedly deficient curvature where the full-line observed curves swing over to the higher part of the saturation line.

It is because of the restricted range of this type of equation that it is permissible to omit the covolume term b or pb. This was done in the writer's steam equation of 1920, which was not intended to be used much above one-half of the critical pressure of 3200 lb.

In Fig. 9 is shown a function pv which is dependent upon the two variables p and T. Really, of course, such a relationship is made graphic by a three-dimensional or "solid" curved surface in which lie the lines or curves that are projected into the one plane of drawing or of representation. The isotherms are plane sections, each the intersection between the relation surface and a plane parallel to the drawing plane, at a particular temperature height t. The saturation boundary is not a plane curve,

but is one view or projection of the three-dimensional intersection of two distinct parts of the surface. Inversion locus NN is another nonplanar curve.

Much interest attaches to the constant-pressure cross-sections of the pv-p-T surface, made by planes of which the traces or edge-on views appear as horizontal straight lines in Fig. 9. These are given in Fig. 11, but not to the full range of pressure. In order to avoid overlapping of curves they are kept below the active influence of inversion of the isotherms. Drawn for pv on t, each curve can also be taken to show v on t, with a different vertical scale at each pressure. Line BB is the zero-pressure or ideal value of pv, or it is $(pv)_0 = rT$. Below the critical pressure the characteristic form is $DEFG$, with liquid state along DB, vaporization from E to F, then expansion of the superheated vapor or the gas. Above p_k the shape HJL is characteristic. Again, the saturation boundary AKC is the junction of two curved surfaces, and plane curves such as DE and HL do not lie in the surface AKC.

In order that the relation of pv or v to p and T might be expressed by an equation of the form of [4] it would be necessary to find a function of p that would give the (whole) isotherms in Fig. 9 and a function of T that would give the p-constant curves in Fig. 11. Obviously, neither set of curves shows a functional form that could be at all simple; and whether it is possible to find and combine suitable functions of unrestricted complexity is extremely doubtful. In fact no one has ever expected or proposed that an equation in these terms shall have more than a limited range, up into the region of high pressure.

Pressure on Temperature and Volume

As already stated, the inclined lines (or planes) in Fig. 9 radiating from the origin, are lines of constant volume; and from the intersections of these lines with the isotherms of that

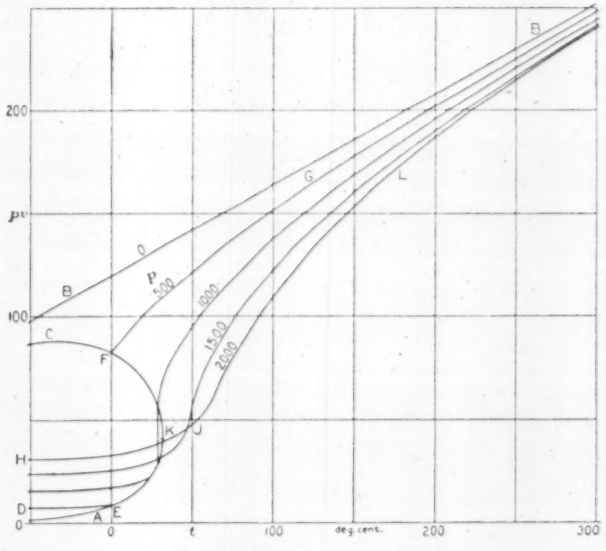

Fig. 11 Curves of Constant Pressure, Horizontal Cross-Sections of Fig. 9 or 10

figure the new plot in Fig. 12 is made. This is like Fig. 6 as to coordinates, but there is a clockwise rotation that makes base w vertical and ordinate pv horizontal. It should be understood that the full-line curves are isotherms, each limited by a cross mark at the top pressure of Fig. 9. The zero-degree curve BD hits saturation boundary CKA at D, and above that point is characterized by constant pressure as well as constant temperature. The dotted p-constant curves—except to the left of boundary CKA—are not plane curves, since temperature is higher as volume v is less or weight w is greater. In the plane of this diagram they project as equilateral hyperbolas; for if p is constant, the product of the two coordinates of Fig. 12 is

$$pv \times w = pv \times \frac{1}{v} = p = \text{const.}$$

On a direct base of specific volume, as in Fig. 5, this curve (really the profile of a curved surface seen edge-on) would change

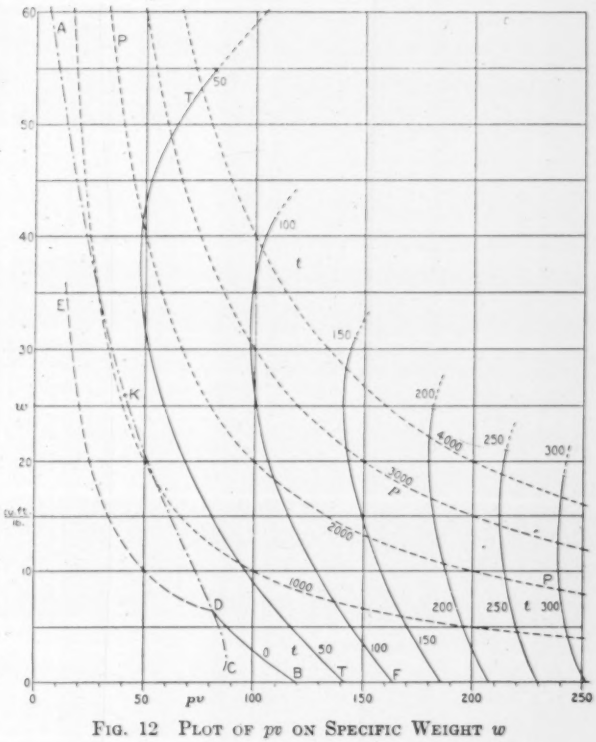

Fig. 12 Plot of pv on Specific Weight w

to an inclined straight line, similar to the p-constant type of line in Fig. 9.

Constant-volume or constant-density cross-sections of Fig. 12—which are also sections of Fig. 9 along the inclined w-constant lines—are given in Fig. 13. These are closely analogous to the constant-pressure sections of Fig. 9 that appear in Fig. 11, but now it is a question of the variation of p with t as represented by pv on t. All of these curves cut across the saturation boundary and lie in the surface within that boundary; if the curves were drawn to show p to a uniform scale (instead of pv), the portions to the left of AKC would merge into one. This curve, really the profile of a surface perpendicular to the plane of drawing, would simply show the relation of saturation pressure to temperature.

Comparing Fig. 12 with Fig. 9 and Fig. 13 with Fig. 11, a great advance toward simplicity of form is apparent. This showing of greater simplicity—with evidently a much higher possibility of mathematical formulation—is another phase of the fact that all attempts at a rational p-v-T equation have been from the side of p as a function of T and v. The next step will be to try out several of these equations, against the graphical formulation of the properties of CO_2.

While these equations do have a rational basis for the form of contractive term Y (see Fig. 6), being derived synthetically from certain concepts of molecular behavior, there will be here not even a brief recapitulation of the theory which they express.

Rather, the overall validity of that theory will be tested by the degree of conformity of equation to experimental fact.

THE OLDER AND SIMPLER EQUATIONS

The older and simpler equations conform to the concepts expressed by the dimensions on Fig. 6. Carried forward from Eq. [3], the complete basic formula is

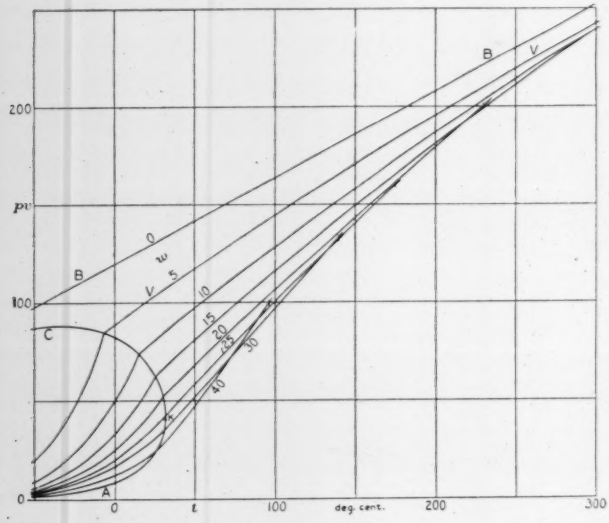

FIG. 13 LINES OF CONSTANT VOLUME OR DENSITY, pv ON T

$$(p + y)(v - b) = rT$$

$$p + y = p' = \frac{rT}{v - b} = rT\,\frac{w}{1 - bw} \quad \ldots\ldots [6]$$

or

$$pv = \frac{p}{w} = \frac{rT}{1 - bw} - Y = p'v - Y \quad \ldots\ldots [7]$$

Quantity y, since it shows the effect of molecular attractions in diminishing the confining pressure p' that would otherwise be required, has been called the "internal pressure" of the substance. Term Y is simply vy or y/w.

Van der Waals (in 1873) first proposed a complete equation of this type, in which

$$y = \frac{a}{v^2} = aw^2 \qquad Y = \frac{a}{v} = aw$$

and

$$pv = \frac{rT}{1 - bw} - aw \quad \ldots\ldots [8]$$

With v or w constant, p or pv would vary directly with T, or the lines in Fig. 13 would be straight, instead of having the slight curvature which they really show.

Berthelot in 1900 proposed the contractive term

$$y = \frac{a}{Tv^2} \qquad Y = \frac{a}{Tv} = \frac{aw}{T} \quad \ldots\ldots [9]$$

which gives to the w-constant lines their actual kind of curvature. In either form of expression for pv there are three coefficients, r, b, and a. Of these r is a definite physical constant, having for CO_2 the value 0.4392 with the units here used. The other two might function as indeterminate coefficients, to be fixed by the coordinates of two locations of the state point; but b properly has a physical meaning and value, more or less closely indicated by data as to the volume of the liquid.

Several variations of the van der Waals equation are shown by Figs. 14 to 17, on small reproductions of Figs. 13, 12, and 9. The first, trial A, treats b as a mere numerical constant, and the equation is fitted to the two circled points in Fig. 14, on the 10-lb. density line. At small densities this fits fairly well; but constant b has come out so big that in the higher range the formula runs wild. Note in Fig. 14 how far the dotted 20-lb. line has moved from the experimental full line. Trial B, not shown in the first type of plot, is similarly fitted to the two circled points on the 30-lb. line in Fig. 15—which was chosen for what was really the first trial, because it is a straight line. This also is not at all a good solution, and is shown chiefly because it offers a first example of a deep drop in the mixture region, or below the saturation boundary, in Fig. 17.

In trial C quantity b is recognized as the covolume, with a value indicated by the 0-deg. liquid isotherm in Fig. 9; and a point on the 15-lb. density line fixes constant a. This runs fairly well with the 150-deg. isotherm in Figs. 16 and 17, but is badly out at low temperatures. These rather poorly guided trials are

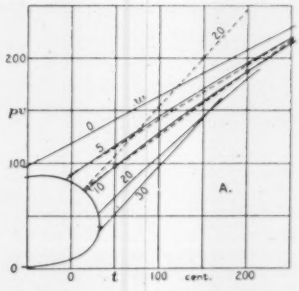

FIG. 14

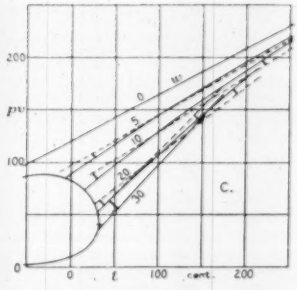

FIG. 15

FIGS. 14 AND 15 TRIALS OF THE VAN DER WAALS EQUATION

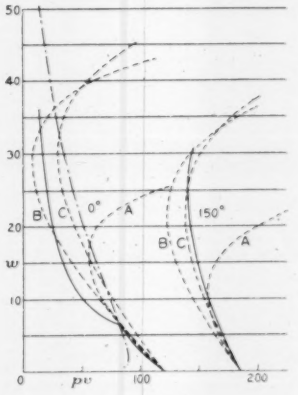

FIG. 16 In the Plot of pv on w

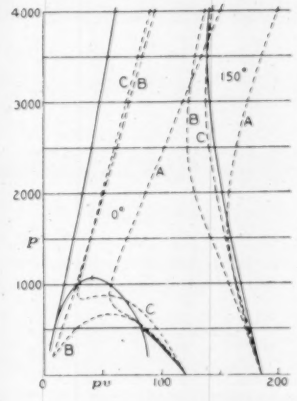

FIG. 17 Transferred to the Diagram of pv on p

FIGS. 16 AND 17 VAN DER WAALS TRIALS IN THE TERMS OF FIGS. 12 AND 9

shown in order to give an idea of the kind of result that will be obtained in first attempts at valuating even so simple an equation.

The constants found for these three trial equations are

A	$b = 0.0264$,	$a = 9.5$
B	$b = 0.0171$,	$a = 8.0$
C	$b = 0.0155$,	$a = 6.5$

The most striking effect of size of b is to determine how soon

the isotherms swing to the right, as they rise in Fig. 16. In this respect and on the whole, there is improvement as b is smaller.

Other data indicate that b should be about 0.0135. With this datum and further adjustment the van der Waals equation

$$pv = \frac{0.4392T}{1 - 0.0135w} - 5.6w \quad \ldots\ldots\ldots\ldots [10]$$

is brought into the excellent agreement with the 150-deg. isotherm that appears in Fig. 19. But, as shown by the few dash lines in Fig. 18 and the curve marked W in Fig. 19, it still makes pv run too big at low temperatures.

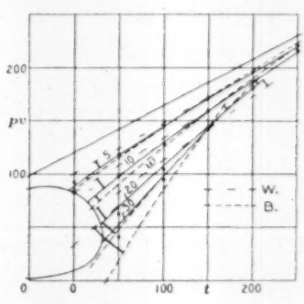

Fig. 18

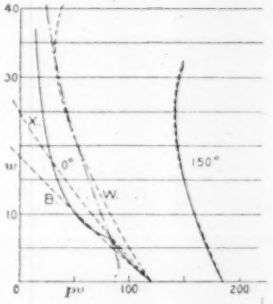

Fig. 19

FIGS. 18 AND 19 COMPARATIVE TRIALS OF THE VAN DER WAALS AND BERTHELOT EQUATIONS

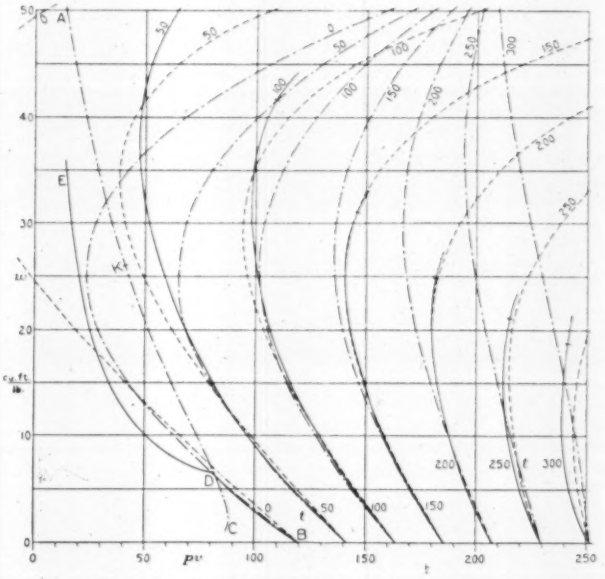

FIG. 20 EQUATION [12] (DOTTED LINES) AND EQUATION [14] (DOT-AND-DASH LINES) PLOTTED ON FIG. 12

The Berthelot form of term Y overcomes the difficulty just described, but is found to go too far. Keeping the same b and the same 150-deg. isotherm, or making

$$5.6w = \frac{a_b}{423}, \text{ whence } a_b = 2370 \quad \ldots\ldots\ldots [11]$$

the Berthelot value of a is found. Now term Y gets too big at low temperatures, making pv run small.

An obvious idea is to use a smaller power of T, and several trials have determined the formula

$$pv = \frac{0.4392T}{1 - 0.0135w} - \frac{211w}{T^{0.6}} \quad \ldots\ldots\ldots\ldots [12]$$

which again keeps the good isotherm at 150 deg. cent. Results are shown by the dots in Fig. 18 and by the curve marked X in Fig. 19; and this equation is carried into the comparisons in Figs. 20 and 21.

VARIOUS EQUATION FORMS

Of the numerous equations of state that have been proposed,[3] a considerable proportion follows the general form of the van der Waals equation, with two types of modification. These are:

(*a*) Keep $p'v = rT/(1 - bw)$ the same and modify term Y; besides the a/v or aw of van der Waals and the a/Tv or aw/T of Berthelot, the following have been used:

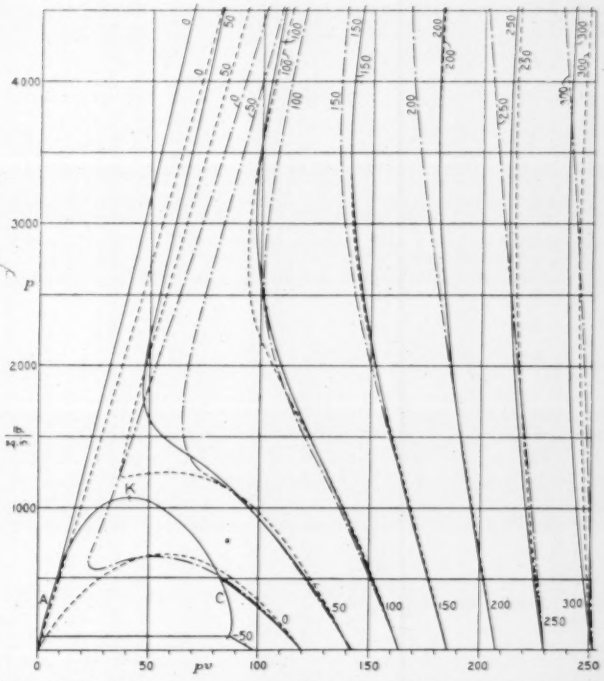

FIG. 21 THE COMPARISON OF FIG. 20, TRANSFERRED TO THE COORDINATES OF FIG. 9

$$\frac{a}{v^n}, \quad \frac{av}{v + c}, \quad \frac{av}{(v + c)}, \quad \frac{av}{(v + c)^2}, \text{ and } \frac{av}{T(v + c)^2}$$

and the writer's form in Eq. [12] is another variation.

(*b*) Apply to rT some other factor than $v/(v - b)$; simpler forms that have been so used are

$$\frac{v + b}{v}, \quad \frac{v + 3b}{v + b}, \quad \frac{v}{v - bT}, \quad \left(\frac{v}{v - b}\right)^4$$

The two variations may be separate or combined, and each kind runs into more complex forms. Also, many equations of more intricate and physically much less obvious type have been devised.

It is evident that this is a big and complex subject, on which a great deal of work has been done without any satisfactory conclusion as yet. To review the whole field would be a tremendous and in many cases a not very profitable task. The intention

[3] In "The Specific Heat of Gases," Partington and Shilling, a list of about fifty-five of these equations is given.

here has been merely to present the general features of the problem and some possible results. To the simpler forms thus far reviewed and applied another equation of more complex type will be added, namely, that of Beattie and Bridgeman,[4] published in 1927. In Figs. 20 and 21 this is brought into comparison with Eq. [12], on reproductions of Figs. 12 and 9.

This equation is

$$pv = rT(1 - E)\left(\frac{v + B}{v}\right) - \frac{A}{v} \quad \ldots\ldots [13]$$

in which A, B, and E are not constants but are functions of v or of v and T. The particular values for CO_2, with volume in cubic centimeters per gram and pressure in atmospheres, are

$$r = 1.865 \quad E = \frac{15{,}000{,}000}{vT^3} \quad B = 2.381\left(1 - \frac{1.6443}{v}\right);$$

$$A = 2.586\left(1 - \frac{1.6210}{v}\right)$$

With the units here used and with specific weight w in place of v, this reduces to

$$pv = 0.4393T\left(1 - \frac{240{,}400}{T^3}w\right)(1 + 0.03816w - 0.001054w^2) - (9.763w - 0.2536w^2) \quad \ldots\ldots [14]$$

which is much easier to compute than might appear from a first inspection.

[4] Publications of the Massachusetts Institute of Technology, No. 199, from the Research Laboratory of Physical Chemistry.

In Figs. 20 and 21 the full-line curves are from Figs. 12 and 9; the others come from Eqs. [12] and [14] and are distinguished by kind of line. A few outstanding points may be noted, as follows:

1 Equation [14] is adjusted to much the better fit on the low-temperature isotherms, at 0 and 50 deg. Curves A in Figs. 16 and 17 show what tends to happen when the simpler form is adjusted to the 0-deg. isotherm. It runs wild in the other regions.

2 Equation [12] is remarkably good in the mean temperature range from 100 to 200 deg.

3 The "experimental" isotherms at 250 and 300 deg. run low in comparison with either formula, but the validity of these extrapolations is doubtful. In simplest terms the question is: Should the w-constant curves in Fig. 13 run higher at their upper right-hand ends, with earlier and more rapid approach to the ideal line BB? Apparently they should.

4 Beyond a region that is comparatively restricted as to both pressure and temperature, the intricate Equation [14] departs radically from correct physical form.

This short investigation does not offer a working equation nor does it open up an optimistic view as to the probability of a closely fitting general equation for steam. It indicates that such an equation should be of a simply rational form that will tend to follow the well-established general behavior of gases over wide ranges of condition; or that, if a more intricate form is found necessary in order to conform to data within the range of experiment, then this should surely be tried out as to its trends over wide ranges of temperature and pressure.

High-Speed Forging Presses

THE columns, which are made of high-quality forged steel, are of the greatest importance, as on the connection between the upper and lower portions depends much of the satisfactory working of the press. The columns are set in place by means of special centering devices, and when centered accurately are secured by a taper device which prevents any movement, so that the column does not work into the press casting, a feature quite common with the older designs of machine. To insure that the column nuts do not slack back, the column is heated by the insertion of a red-hot rod into a bored hole, and the nut screwed up while the column is in that condition.

The crosshead holding the top forging tool, and receiving its motion from the main ram, slides on the columns. In the new designs the columns are made square, so that wear can be readily taken up by the long cast-iron slippers inside the crosshead. Further, the square section gives greater strength in a lateral direction, which property is highly important, because during the forging operations it is quite probable that the forging load may be applied at a point considerably out of center, due to the shape of the forging or bad manipulation. This causes an unbalanced load which must be resisted by the columns, and a square-section column is most suitable for this service.

The press layout may include furnaces on which waste-heat boilers are fixed to generate the steam used in the forging presses. As regards the utilization of waste heat in forge plants, close examination before installing expensive boilers is advisable. If it were possible to be working the presses continuously, then the efficiency of steam raising would be very important; but all forges stand for a long period, while the material is being heated, and during that time steam is usually blowing to atmosphere. For this reason the actual saving is not of importance compared with quick working of the press.

In a press plant recently installed the money spent, which might have been spent on waste-heat boilers, was added to the price of the press installed, with the result that a larger intensifier than usual was supplied. This gave a deeper penetration when working on a forging, so that work which had required three heats could be done in two, and other work was completed in one operation. This continuous saving over the whole year was much greater than could be obtained by any boiler or saving of steam on the actual press by gears.

In small forges using 800-ton presses the expenditure of coal in the earliest design was 15 cwt. per ton of ingots heated. Now it is possible to save at least 5 cwt. of fuel per ton of ingots solely by making faster presses, and this fuel utilized in the power-station boilers is much more efficacious than when burned in the forge furnaces.

In large furnaces it takes anything from 18 to 24 hr. to heat an ingot of 70 tons, but if it could be charged warm into the furnace, anything from 6 to 9 hr. could be saved. During a great part of the heating period steam would be blowing off, unless it were in a forge with many presses, when it could be delivered into the ring main, or otherwise piped away to other parts of the works.

The author tells of some large forgings, particularly solid-forged drums for high-pressure boilers and for the chemical industry, and in conclusion says that there seems to be something wrong about the design of forge furnaces, which is made particularly difficult because of the large number of widely varying factors involved. Because of this it seems to him to be advisable to concentrate on the press equipment to obtain greater speed rather than on the furnace where calculated efficiencies are difficult to attain. (F. H. R. in *Mechanical World*, vol. 84, no. 2184, Nov. 9, 1928, pp. 435–437, 3 figs.)

Progress in Steam Research

Reports of Work Carried Out at the Bureau of Standards and the Massachusetts Institute of Technology, and in Czechoslovakia

THE seventh annual session on Progress in Steam Tables Research was held on the afternoon of Wednesday, December 5 during the 1928 Annual Meeting of the A.S.M.E. Dean Arthur M. Greene, Jr., Past Vice-President of the Society, presided.

Geo. A. Orrok, Chairman of the Executive Committee, Steam Table Fund, reported on the financial status of the research. F. G. Keyes and L. B. Smith stated that the work of the year had provided data which enabled them to decide definitely certain questions pertaining to the reliability of the indications of their earlier thermometers and the constancy of the volume of the measuring bomb after being subjected to pressure at high temperatures; also that the containers for completing the superheat observations had been calibrated for volume and would soon be ready for measurements of thermal dilation, and that the observations would undoubtedly be finished before the close of another year. N. S. Osborne, H. F. Stimson, and E. F. Fiock told of this work at the Bureau of Standards on the determination of the heat capacity of water between 0 and 270 deg. cent., and gave tables of the resulting values.

Following these reports, which appear below, Prof. J. H. Keenan read a paper in which he presented a revision of the Mollier chart developed in 1925 which is extended to 3500 lb. per sq. in. and 1000 deg. fahr. Professor Keenan's paper is published in this issue on pages 109-115.

Prof. R. C. H. Heck then presented a paper which discussed the possibility of establishing correct general equations of unrestricted range for relating the properties of steam. This paper will be found on pages 116-122 of this issue.

In conclusion Dr. Harvey N. Davis discussed briefly his work in correlating the data already obtained.

A communication from Professor Havliček, of Czechoslovakia, received after the meeting, appears on page 127.

Report of the Executive Committee of the Steam Table Fund

GEO. A. ORROK, Chairman of the Executive Committee of the Steam Table Fund, reported as follows:

At the December, 1927, Annual Meeting the Executive Committee of the Steam Table Fund reported receipts up to December 1, 1927, amounting to $57,749.65, with disbursements to the same date of $56,434.71, leaving a balance on hand of $1314.94. As of December 1, 1928, the financial condition of the fund stands as follows:

Receipts:	
Previously acknowledged	$57,749.65
Additional receipts	5,706.32
	$63,455.97
Disbursements:	
Previously reported	$56,437.71
Additional disbursements	6,501.34
	62,939.05
Balance on hand	516.92
Total	$63,455.97
Special Account:	
Borrowed from A.S.M.E.	$15,000.00
Payments to M.I.T.	8,814.79
Balance of A.S.M.E. loan on hand	$ 6,185.21

The total amount spent up to date has thus been $72,270.76, besides which Harvard University has spent in the neighborhood of $15,000 for various expenses in connection with the research on the Joule-Thomson effect. The Bureau of Standards has expended over $30,000 in its work, and the Massachusetts Institute of Technology has expended possibly $20,000 which might have been charged up against this investigation.

This research was started on June 23, 1921, and has been pressed with the utmost celerity to the present time. During these seven years the work on the Joule-Thomson effect at Harvard University has been completed and is ready for publication in detail, the corrected points having been published two years ago in the A.S.M.E. Transactions.

The work at the Massachusetts Institute of Technology is being carried on continuously and more than 200 points have been secured, mostly in the liquid and vapor phase. Experiments running up to 4300 lb. per sq. in. have been completed, and Dr. Keyes will report on the work of 1928 and the difficulties which he has encountered in going into the vapor phase with its attendant larger volumes.

Messrs. Osborne and Stimson will report on the work at the Bureau of Standards, where the determination of the specific heat of liquid water is being gradually extended and certain measurements of the total heat of saturation have been obtained.

The Committee has been greatly encouraged by the results which have been obtained, and particularly by the active interest shown by the men in charge of the work and the organizations which they represent.

The Committee has received from the Masaryk Academy in Czechoslovakia some determinations of the total heat of steam at high pressures and temperatures which were presented before the Fuel Section of the World Power Conference during the London meeting in September. Dr. Havliček, who has been doing this work—which was started by Dr. Zvoniček and himself—has sent us his curves and will make the whole of his work available for checking up by American investigators.

In Germany Dr. Knoblauch is about ready to publish his latest investigations on the specific heat of superheated steam, which should be available early in 1929.

Dr. Callendar in England has just presented a paper before the Royal Society noting discrepancies at or around the critical point. It is unfortunate, however, that he has not made public the data on which he bases his conclusions.

At the meeting of the Fuel Section of the World Power Conference in London last September, I had the opportunity of meeting with the Committee of B.E.A.M.A., which has been in charge of the experiments which have been made under Dr. Callendar's direction, at the College in South Kensington. I also met Dr. Jakob and some of the other German investigators while in Berlin, and at the London meeting, I met Dr. Havliček. The general feeling on the other side of the water is that no final publications should be made until an international understanding concerning the data has been obtained. Among other organizations the I.E.C. is greatly concerned on this point, and the Committee has agreed with the English Committee and the German and Czechoslovakian representatives that no final steam table shall be printed until all of the results of the various experimenters have been submitted to criticism and checked and an international agreement has been secured. Plans looking toward

this end are already in hand, and the Executive Committee hopes to make an announcement concerning them later on in 1929.

Report on Progress in Steam Research at the Massachusetts Institute of Technology

BY FREDERICK G. KEYES[1] AND LEIGHTON B. SMITH,[1] CAMBRIDGE, MASS.

THE past year's work has provided further data enabling us to decide definitely regarding certain questions pertaining to the reliability of the indications of our earlier thermometers and the constancy of the volume of the measuring bomb after subjection to pressure at high temperatures.

The apparatus for measuring the thermal dilation of the material from which the volume containers were made has been received from the Zeiss Company in Germany. The thermal-expansion data will enable a final computation to be made of the several series of measurements of liquid and vapor volumes.

The cost of new equipment for measuring thermal expansions has been met from the budget of the Research Laboratory of Physical Chemistry, and it is believed to be the best and most satisfactory modern equipment for ascertaining the thermal expansivity of solids.

The delaying hand of misfortune has not neglected to touch us during the year. The large closure cone of the nickel container began to give trouble, and also the small connecting tube. The container itself finally gave way, necessitating the construction of a new container. The material chosen, however, was not nickel but chrome-vanadium steel.

THERMOMETRY

When the work was started in 1923 we had available "pure" platinum wire obtained in England and America. The platinum was not as pure as desirable, but it was the best obtainable at the time. Subsequently, through the courtesy of the Bureau of Standards, we were enabled to obtain platinum in the wire size desired for resistance thermometers. The purity of the Bureau platinum is the best obtained in the course of some eighteen years of experience with wire for platinum-resistance thermometers.

The thermometry is of such fundamental importance that it may be well to recall that the following thermometers have been used in taking data.

No.	Platinum used	Type	Remarks
1	American	Flat	1923
2	Bureau of Standards	Flat	Lost due to leak in sheath
3	Bureau of Standards	Strain-free	Unsuitable due to contamination of platinum from steel sheath
4	Bureau of Standards	Strain-free	Helium-filled
5	Bureau of Standards	Strain-free	Neon-filled

The "flat-type" thermometers possess certain advantages in the rapidity with which the resistance coil acquires the temperature of the bath in which the thermometer is placed. The greater lag of the strain-free type, which is a better precision instrument than the flat type, is reduced somewhat by filling the case with hydrogen, helium, or neon, and hermetically sealing. From the point of view of rapidity of heat conductivity, hydrogen is better than helium, and the latter better than neon. Consideration must, however, be given to a possible effect of the gas on the platinum-resistance coil, and while no positive indication is yet available as to the preferred gas, helium seems to be entirely suitable.

All early measurements to 300 deg. cent. (572 deg. fahr.) were made with thermometers Nos. 1 and 2. The failure of the sheath of No. 2 involved a difficulty, but we now possess a very satisfactory intercomparison between the various thermometers. Thermometers Nos. 4 and 5 are entirely reproducible, and so far as can be determined are entirely satisfactory. The No. 5 thermometer is reserved as a reference standard, while its mate, No. 4, is in constant use in taking data.

THE VAPOR-PRESSURE CURVE

There is presented herewith a "deviation" plot, Fig. 1, indicating graphically the per cent differences in pressures as a function of temperature. The plus ordinates mean that the M.I.T. measurements are greater than those of the Reichsanstalt. The values of the vapor pressure obtained by the Reichsanstalt have been reduced (see "International Critical Tables," vol. 3, p. 233) to the Callendar-formula temperature scale of the platinum-

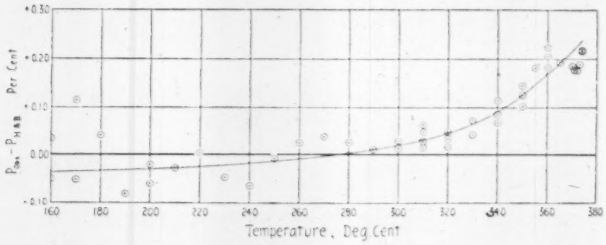

FIG. 1 DIAGRAM SHOWING PER CENT DIFFERENCES IN PRESSURE AS A FUNCTION OF TEMPERATURE

resistance thermometer, using 444.6 deg. cent. (800.28 deg. fahr.) as the sulphur normal (1 atmos.) boiling point. This curve is slightly different from that previously presented due to a final decision's having been reached regarding the interpretation of some of the temperature readings obtained with thermometers Nos. 1 and 2. It should be stated that a further series of vapor-pressure measurements will be available in connection with the superheat work now in progress. We are chiefly desirous of further measurements at lower temperatures, 150 deg. cent. to 250 deg. cent. (302 deg. fahr. to 482 deg. fahr.). The measurements which we have were made in the earlier part of the work, and, while satisfactory, the consistency of duplicate measurements is believed not to be all that the apparatus is capable of yielding.

SUPERHEAT VOLUMES

The hope had been entertained a year ago that at this meeting we should be able to present a substantial extension of the superheat field over that already presented. The evil genii of the experimenter decided otherwise, as the ruptured high-pressure container testifies. Before the rupture occurred, however, some duplicate measurements were obtained with fresh loadings of water leading to values given in Table 1. In this table the part of the data presented last year is given. The table contains pressures corresponding to the temperatures listed in column 1,

TABLE 1 SUPERHEATED-STEAM MEASUREMENTS
(Partial check of previously reported measurements)

T, deg.	10 cc. per gram Series 6, atmos.	Check, per cent	12.5 cc. per gram Series 6, atmos.	Check, per cent	15.0 cc. per gram Series 6, atmos.	Check, per cent	17.5 cc. per gram Series 6, atmos.	Check, per cent	20.0 cc. per gram Series 6, atmos.	Check, per cent	T, deg. cent.
310	....	.....	....	.....	....	.....	.....	.....	92.01	−0.022	310
320	....	.....	....	.....	.....	.....	103.80	+0.010	95.75	−0.010	320
330	....	.....	.....	.....	118.01	+0.034	108.17	+0.019	99.40	+0.040	330
340	....	.....	135.28	+0.044	123.23	+0.024	112.38	+0.027	102.92	+0.078	340
350	156.31	+0.038	141.73	+0.049	128.27	+0.031	116.49	+0.069	106.34	+0.038	350

Total average deviation = 0.036 per cent.

[1] Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology. Publication No. 218.

and for volumes given in the top horizontal row of the table. The columns marked "check per cent" refer to the differences between the old data and those obtained with the new water loadings. The plus sign signifies that the earlier measurements of pressure exceed the duplicate series.

The excess of plus signs is probably due to the fact that these measurements were made just previous to the failure of the container. In any event, the average deviation of the independent measurements amounts to about one part in twenty-eight hundred, and further measurements will be made in this region of the superheat, employing the new high-pressure container now completed.

UNREDUCED DATA

All the observational data relative to liquid volumes and liquid compressibilities await the completion of the thermal-dilation data for the nickel container before final values can be given. As referred to above, the apparatus for these measurements has arrived from abroad and the samples are ready for the work. The importance of an accurate knowledge of the thermal dilation will be perceived when it is recalled that at 370 deg. cent. (698 deg. fahr.) the correction for dilation amounts to about 1.6 per cent.

OBSERVATIONS IN PROGRESS

The containers for the completion of the superheat observations have been described in detail in the reports of the previous years. These containers have been calibrated for volume, and specimens of the material of each bomb are ready for the measurements of thermal dilation. A complete series of water samples are also ready, and in a very short time the first series of observations with the low-pressure containers will be in progress. Two identical containers are available, one of which may be loaded while the other is in use, thus keeping the measuring apparatus in as continuous use as possible. The expectation at present is that the observations will be finished before the close of another year.

A word about the range of the superheat measurements planned may be apropos at this time. The extreme temperature at which measurements will be carried out will be 450 deg. cent. (842 deg. fahr.) and for volumes varying from 5 cc. per gram (0.08 cu. ft. per lb.) to 300 cc. per gram (4.8 cu. ft. per lb.). The lower limit of temperature will be about 150 deg. cent. (302 deg. fahr.).

The equation-of-state problem for substances of the type of water is more complicated than for substances of the type, for example, of nitrogen. The new extensive data for steam, however, together with much unpublished data for a similar substance, ammonia, will be of important scientific value in testing certain theoretical deductions which have been obtained. With a satisfactory equation of state for steam, reproducing satisfactorily the experimental data, there should be entire confidence in the use of such an equation for all purposes of interpolation and even moderate extrapolation.

Report on Progress in Steam Research at the Bureau of Standards, With Determinations of the Heat Capacity of Water Between 0 Deg. Cent. and 270 Deg. Cent.[2]

BY N. S. OSBORNE,[3] H. F. STIMSON,[3] AND E. F. FIOCK,[4]
WASHINGTON, D. C.

THE work here reported consists of determinations of the heat content of saturated liquid water. The apparatus and methods used have been described in previous reports to this body. Briefly stated, the method employed consists in adding heat, developed and measured electrically, and distributed mechanically to a sample of water confined in a metal container so isolated from other bodies that the heat added is used to raise the temperature of the container and water sample. Initial and final temperatures are observed when liquid and vapor are in equilibrium. By measuring the heat added for both large and small samples of water, the heat capacity of a water sample is determined over the chosen range of temperature independently of a knowledge of the heat capacity of the calorimeter.

In these experiments the mass of the water samples ranged from about 250 grams to 500 grams, or roughly from about half a pound to a pound. The water equivalent of the calorimeter is about 210 grams. For several reasons it is convenient to consider the results in three groups with respect to the temperature range covered.

The first group consists of the measurements between the normal freezing and boiling points. This group furnishes the basis for the determination of the value of the mean calorie in electrical or mechanical units of energy, reported a year ago. In addition it yields values for the specific heat of water at intermediate temperatures. This is of interest in so far as it furnishes a basis for correlating calorimetric work in terms of various calories.

In this first group 162 experiments were made, in most of which the temperature intervals covered were 10 deg. cent. Several covered the entire range in a single experiment as a check on the summation giving the value of the mean calorie in electrical units of energy. There were in addition a few covering shorter intervals at the lower temperatures.

The second group comprises 130 experiments covering the range from 100 deg. cent. to 210 deg. cent. (275 lb. per sq. in.), also made in 10-deg. steps, and is the basis for the values of the heat content of saturated liquid water in this range.

This range of the work had been partially covered experimentally a year ago when we reported that up to this point the apparatus had functioned in a satisfactory manner, except for minor incidental difficulties which were readily overcome.

The third group extends from 200 deg. to 270 deg., the latter temperature corresponding to about 800 lb. per sq. in. Our experience in this range has not been so fortunate as in the earlier work, and has emphasized the difficulties to be encountered in applying the refinements necessary to secure high precision in the calorimetry of a saturated fluid at high pressures. Accurate calorimetry necessitates the accurate measurement of mass of fluid, energy supplied, and changes of temperature produced. The control of each of the three classes of leaks which must be avoided, namely, fluid, electrical and thermal, becomes more difficult as the range of temperature is extended.

Without enumerating all the details of these difficulties which have been actually met, it may be said that although we have not yet succeeded in obtaining results in this higher range as trustworthy as in the two previous groups, we are able to give figures for the heat content from one group of 37 experiments just completed which represent our best experimental values to date for this property of water.

During the course of this work it has been necessary to completely dismantle the calorimeter in order to repair a broken ball bearing in the circulating pump. This failure occurred only after about a year of nearly continual service during which the pump had made probably 100 million revolutions, and while it necessitated a distressing delay, the repairs and reassembly were successfully accomplished.

Several other partial dismantling operations were made necessary by difficulties incident to the invasion of the higher temperature range.

[2] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.

[3] Physicist, Bureau of Standards.

[4] Associate Physicist, Bureau of Standards.

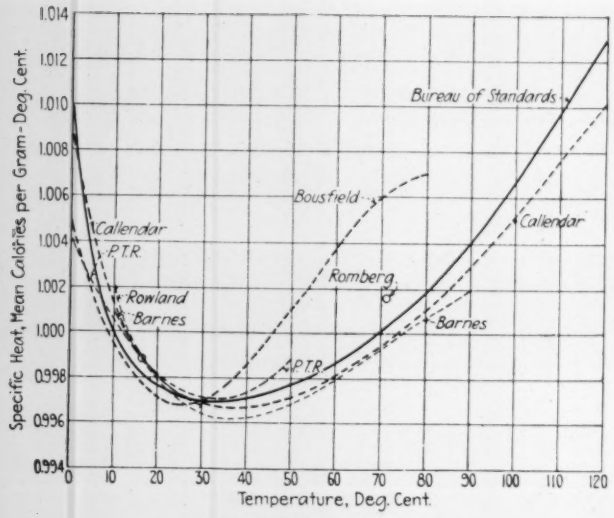

FIG. 2 SPECIFIC HEAT OF WATER

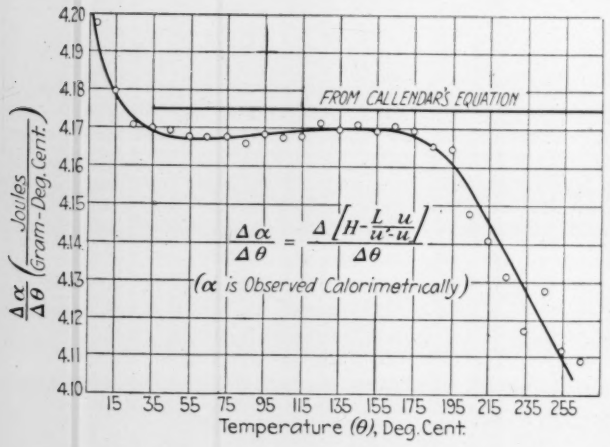

FIG. 3 QUANTITY DIRECTLY OBSERVED IN EXPERIMENTS

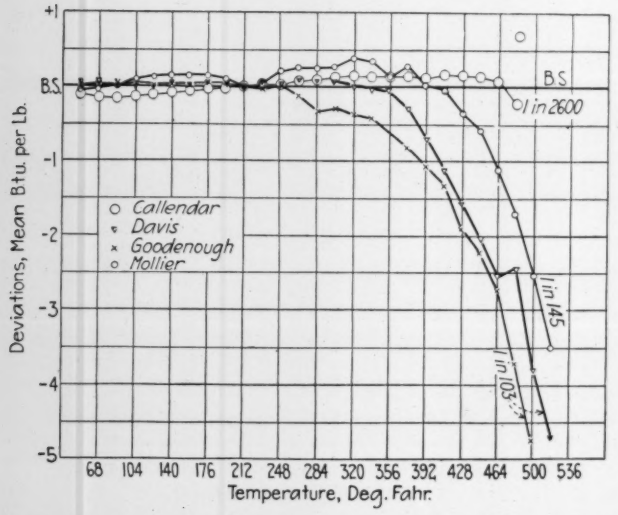

FIG. 4 DEVIATIONS IN TOTAL HEAT OF WATER FROM BUREAU OF STANDARDS VALUES

It appears that the effort expended in covering the sixty degrees from 210 deg. to 270 deg. has been nearly as great as that required to reach 210 deg., to say nothing of the anxiety as to the final successful outcome of the work.

While the results are not entirely as satisfactory as we yet hope to make them with further work in this and the still higher range to 300 deg. cent. (1240 lb. per sq. in.), nevertheless they do definitely indicate the trend of the heat content sufficiently well to serve as a reliable basis for appraisal of the figures given in existing tables of this property.

The experimental determinations of heat capacity of water give as a direct result, in international joules, the increase in the quantity $H - L\frac{u}{u' - u}$ over the observed range of temperature, in which H denotes the heat content of the saturated liquid, L the heat of vaporization, and u and u' the specific volumes of saturated liquid and vapor, respectively. The term $L\frac{u}{u' - u}$ has been computed from existing steam tables, and the values of H which we give are tentative to the extent of the uncertainty of these data. Our experimental program includes the direct measurement of this quantity, and a number of determinations have been made already.

TABLE 2 RESULTS OF MEASUREMENTS OF HEAT CAPACITY OF SATURATED LIQUID WATER

Temp., deg. cent.	$H - \frac{Lu}{u' - u}$ Int. joules per gram	$\frac{Lu}{u' - u}$ Int. joules per gram	H Int. joules per gram	H Mean cal. per gram
10	41.99(a)	0.02(b)	42.01	10.03
20	83.80	0.04	83.84	20.02
30	125.55	0.07	125.62	30.00
40	167.22	0.12	167.34	39.96
50	208.92	0.20	209.12	49.94
60	250.61	0.31	250.92	59.92
70	292.30	0.47	292.77	69.91
80	333.99	0.70	334.69	79.92
90	375.66	1.00	376.66	89.95
100	417.36	1.40	418.76	100.00
110	459.04	1.94	460.98	110.08
120	500.73	2.62	503.35	120.20
130	542.44	3.48	545.92	130.37
140	584.16	4.56	588.72	140.59
150	625.87	5.89	631.76	150.86
160	667.57	7.51	675.08	161.21
170	709.29	9.47	718.76	171.64
180	750.99	11.79	762.78	182.15
190	792.67	14.56	807.23	192.77
200	834.36	17.82	852.18	203.50
210	875.8	21.7	897.5	214.3
220	917.2	26.1	943.3	225.3
230	958.6	31.3	989.9	236.4
240	999.7	37.3	1037.0	247.6
250	1041.0	44.2	1085.2	259.1
260	1082.1	52.1	1134.2	270.8
270	1123.2	62.1	1185.3	283.0

(a) The values given in column 2 are those actually observed. Above 210 deg. cent. the values are tentative subject to additional experimental work.

(b) The values given in column 3 are computed from Mollier's recent steam table. Direct measurements made at 200, 250 and 270 deg. agree very well with these figures, but final values above 100 deg. will be dependent on additional experimental work.

TABLE 3 OBSERVED RELATION BETWEEN THE SPECIFIC HEAT OF WATER AND THE MEAN CALORIE

Temp., deg. cent.	Heat capacity per gram-deg. cent. Int. joules per gram-deg.	Mean calories per gram-deg.
15	4.1807	0.9983
20	4.1775	0.9976
32.5	4.1751	0.9970
70	4.1877	1.0000

In this latter type of experiment liquid water is withdrawn from the calorimeter, while the temperature of the calorimeter is kept constant by the addition of energy at a steady rate. The rate of withdrawal of the water must therefore be under precise control, and for this purpose a throttle valve with a delicate adjustment was placed in the water line outside the calorimeter. Although difficulties with this control were experienced at the outset, they have been successfully overcome, and reliable measurements of this correction term are now in progress.

Table 2 shows the values of heat capacity of saturated liquid water as actually observed to date. An empirical equation has been fitted to these data between 0 and 200 deg. cent. for the purpose of obtaining values of specific heat at intermediate temperatures. The values of specific heat derived in this way between 0 and 100 deg. cent. are shown in Fig. 2 for comparison with data from other observers.

It must be noted that a precision of the specific heat at a given temperature, comparable to that of the mean specific heat over the entire range of 100 deg. is not attainable without increasing the experimental precision in the range where the slope of the heat-content curve is changing most rapidly. For this reason it appears desirable to make some additional measurements on the specific heats at several temperatures to establish a relation between the various calories, comparable in accuracy with that of the mean calorie.

In Table 3 the relation between several calories as given by our experiments is shown.

In Fig. 3 there is shown graphically the quantity directly observed in our experiments up to 270 deg. cent. It is of interest that this quantity appears directly in the simple approximate equation given by Callendar for heat content of the liquid. The straight line shown in the figure is derived from this equation, using the constants from our experiments. It is evident that a straight line may represent fairly well the observations between 0 and 200 deg. cent.

Fig. 4 shows the deviations of the heat content of liquid water given in several existing steam tables from the values in Table 2.

In March of this year the figures for saturated liquid water were furnished Mr. Keenan of the General Electric Company according to our best knowledge at that time for use in compiling a tentative steam table. The figures now given confirm those up to 230 deg. cent., but are about 1 part in 900 lower at 250 deg. cent.

An estimate of the accuracy of the heat-content table is, of course, a rather arbitrary appraisal. Up to 210 deg. cent. we do not expect further work to change the figures by more than 1 part in 3000, and up to 270 deg. cent., by more than 1 part in 1000.

There remains yet much which may be done if the experimental work is permitted to continue. In addition to the heat of liquid between 200 and 300 deg. and more precise specific heats between 10 and 30 deg. cent., the heats of vaporization in the entire range are to be determined.

The question may arise as to whether the struggle for accuracy of some of these properties of a fluid is worth what it costs, or in other words, to what limit it is profitable to pursue the truth on difficult experimental paths. It is possible to undertake so bold and formidable an experimental task that the results appear in the nature of luxuries.

It is therefore with some hesitancy that we refer to a possible extension of our work into the superheat region. We trust the coming year will see the completion of the program of measurements on the saturated fluid undertaken at the request of the Cambridge Conference. If, as recommended by that conference, it should still appear that additional or confirmatory data on the specific heat of superheated steam at high constant pressures are necessary in order to formulate a steam table sufficiently reliable to meet with universal approval, we are prepared to present a proposal for attempting to meet this need after the conclusion of the saturation work. The project would include the design and construction of apparatus based on a flow calorimeter adapted to measurement independently, of heat content, Joule-Thomson effect, and isothermal throttling. A preliminary study of some of the vital constructive features of this undertaking has already been made, models built, and laboratory tests made, indicating the possibility of making accurate experiments at high temperatures and pressures, including cross-checks between three different methods.

Experiments on the Properties of Steam at High Pressures

BY JAROSLAV HAVLIČEK,[5] CZECHOSLOVAKIA

THE present communication gives an account of experiments carried out at the Masaryk Academy of Work (M.A.P.), and a comparison of the results attained with those obtained by Prof. H. L. Callendar, of the Imperial College of Science and Technology, London, and by The American Society of Mechanical Engineers.

The experimental equipment of the M.A.P. was described in a paper presented at the World Power Conference in London

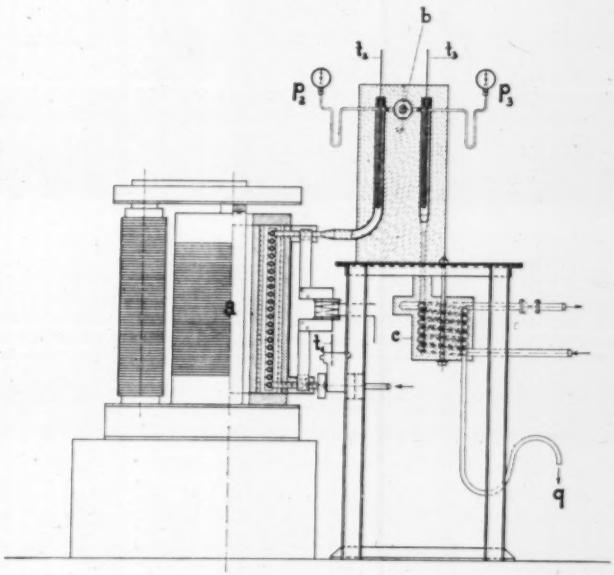

FIG. 5 APPARATUS USED IN THE M.A.P. EXPERIMENTS
(*a*, transformer, boiler; *b*, throttling valve; *c*, condenser.)

(1928) under the title "Researches with High-Pressure Steam," Section J, No. J2. (See also Fig. 5.)

The experiments have been made with distilled water, but not in an air-free condition, and also with standard water as it is used in a boiler plant. Later it is the intention to make some comparative measurements with air-free water.

In each experiment the quantity of heat supplied, the Joule-Thomson effect related to a known condition, about 1.2 atmos. abs., and the heat delivered in the condenser, are measured.

The losses, which are but losses of heat, are eliminated by making two successive measurements, of three hours each after reaching the state of continuity, at equal temperatures and pressures, but with different quantities of steam, and by employing the equations of the quantities of heat supplied and delivered. The corrections referring to the kinetic energy of the flow of the steam, the radiation of the thermometer fittings, etc., are taken into account.

The measurement of the heat delivered to the condenser depends on a knowledge of the specific heat of the water of from about 10 deg. cent. to 80 deg. cent. Up to the present time, however, this has not yet been ascertained precisely, and the values differ even in this temperature range up to 1 per cent, according to the investigator—Lüdin, Dieterici, and

[5] Formerly Professor in Ordinary at the Royal University, Zagreb

Barnes (see "Physikalisch-chemische Tabellen," by Landolt-Börnstein, 1912). In applying the results of the measurements, the method involving the Joule-Thomson effect has been preferred, the heat content as determined by Mollier at about 1.2 atmos. abs. up to 500 deg. cent. being adopted as a basis. The exactness of the heat-content values at the highest steam pressure, ascertained by the M.A.P. at different temperatures and pressures, depends on the exactness of the heat-content

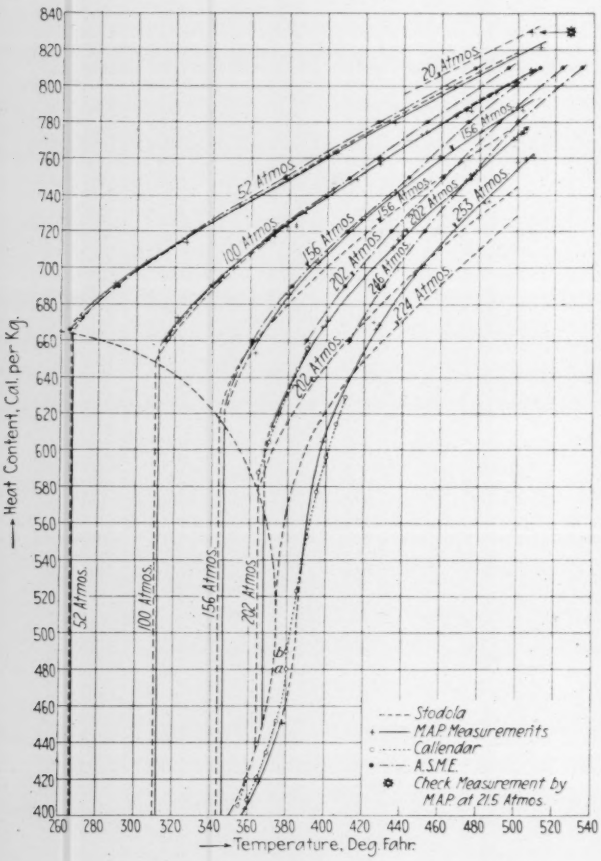

FIG. 6 HEAT-CONTENT VALUES ACCORDING TO VARIOUS EXPERIMENTERS

values at about 1.2 atmos. up to 500 deg. cent. determined by Mollier.

The heat contents of superheated steam at 52, 100, 156, 202 and 253 atmos. abs. have been obtained by 210 measurements made during the period from 1926 up to the end of 1928, and as shown in Fig. 6 lie along the solid-line curves passing through the several points (crosses) which were measured individually. To facilitate a comparison, the heat contents for equal pressures, taken from the entropy diagram in the supplement to the 5th edition of Stodola's "Dampf- und Gasturbinen" in 1924, are shown in light broken lines.

The measurements of the heat content of saturated steam will be carried out by the M.A.P. in 1929 after an adjustment of the experimental equipment, which is the reason why they are shown in the diagram of the M.A.P. as tentative only, and are therefore not to be considered as being sufficiently precise.

The Stodola lines correspond very well with the M.A.P. lines at 52 and 100 atmos. abs.; the deviations are greater at 156 and 202 atmos., which is due to the fact that Stodola, in default of test results, was compelled to extrapolate.

The values for the pressures as measured by us, taken from Prof. H. L. Callendar's "Steam Tables and Equations, Extended by Direct Experiment to 4000 Lb. per Sq. In. and 400 Deg. C." (Royal Society, A, vol. 120, 1928) and from the A.S.M.E. "Total Heat-Entropy Diagram Developed from Davis-Kleinschmidt, Joule-Thomson Tests, Keyes-Smith Specific-Volume Determinations, Bureau of Standard Liquid Heats," given in this issue of MECHANICAL ENGINEERING, are recorded in Fig. 6 as well. In comparing these three sets of values of the heat contents the writer would offer the following views.

1 *M.A.P. and Callendar Measurements.* Here the methods employed are the same, and the results of the measurements harmonize well. In the case of the M.A.P., measurements of the heat contents of saturated steam as well as the definition of the boiling temperatures at different pressures are wanting. In the meanwhile, the M.A.P. assumes boiling temperatures in conformity with the American measurements of 1926.

Professor Callendar has determined the critical point of water to be at 380.5 deg. cent. and 258 atmos. abs., and assumes, on the strength of his measurements, some final specific heat at that point, but not the infinite value that was hitherto supposed. This is why the limit curves for water and saturated steam at the critical point form a peak instead of a line extending indefinitely, as was hitherto thought to be the case.

Consequently, Professor Callendar will still find a heat of evaporation of 9 cal. per kg. at the pressure of 253 atmos. abs., at the points *a* and *b*, Fig. 6. No measurements were made by the M.A.P. in just this zone, hence the broken line of the curve; but such measurements will be made in the near future in order to check the correctness of these very interesting discoveries of Professor Callendar's.

As the measurements by Professor Callendar only extend up to 400 deg. cent., it is to be regretted that a comparison with the M.A.P. results at the higher temperatures is not possible.

2 *M.A.P. and A.S.M.E. Measurements.* The American tests were primarily directed toward the determination of the specific volume of the steam. The measurements extend, according to the present publication, only up to 400 deg. cent.

The value pv/T is determined and its variation at a constant p ascertained. From this variation the heat contents are calculated by the formula

$$\left(\frac{\partial H}{\partial p}\right)_T = -A\,\frac{T^2}{p}\,\frac{\partial}{\partial T}\left(\frac{pV}{T}\right)_p$$

Up to about 400 deg. cent. the heat contents, as given in the American tables, agree very well with those measured by the M.A.P. The deviations at 500 deg. cent., however, are rather considerable. The explanation of this fact would be easy if the A.S.M.E. values above 400 deg. cent. had really been extrapolated, as is stated in an article published in MECHANICAL ENGINEERING, February, 1928.

On receipt of the American tables the M.A.P., in order to get a clear idea of the accuracy of the measurements, carried out by means of their test equipment the following checking measurements:

The heat content of the steam of 21.5 atmos. abs. at 507 deg. cent. was measured in the same way as usual.

Using the method of calculation that had been applied in other previous measurements, it was found that the heat content H was 829.41 cal. per kg. For the same pressure and temperature Mollier's tables give H = 828.66 cal. per kg. and Stodola's, H = 830.5 cal. per kg. The agreement at this very high temperature where the losses in the M.A.P. measurements are the greatest, is thus seen to be very good.

The values of the heat content above 400 deg. cent., as given by the latest American tables, therefore, seem to be too high.

The New Critical-Pressure Tables Compared With Recent Experiments

BY J. H. KEENAN,[6] HOBOKEN, N. J.

THE steam table and chart presented elsewhere in this issue were based on all the experimental data available in April, 1928. Since that time the experimental progress includes a complete experimental check of the Keyes-Smith data which verifies the original values within a few hundredths of 1 per cent;[7] an extension of the Bureau of Standards liquid total heats from 600 lb. per sq. in. to 800 lb. per sq. in.;[8] the Masaryk total-heat measurements;[9] and, most notably, an extension of

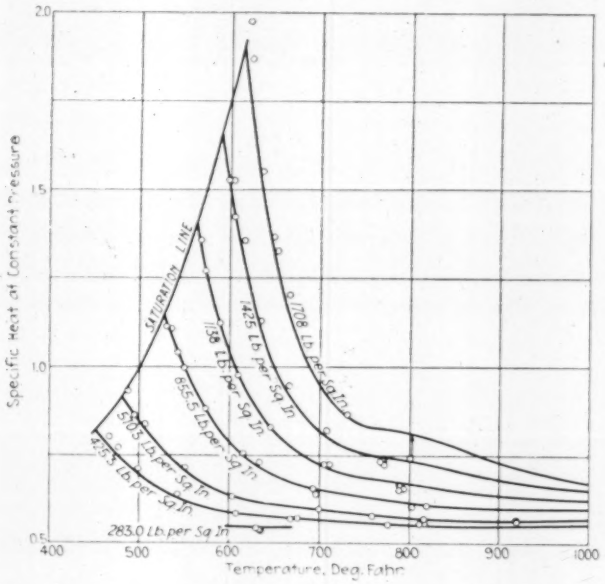

FIG. 7 COMPARISON OF THE SPECIFIC HEATS CALCULATED FROM THE NEW TABLE WITH THE KNOBLAUCH MEASUREMENTS PUBLISHED IN DECEMBER, 1928

(The lines represent the values from the new table; the circles are the Knoblauch measurements. Note that no experimental data were available to aid in the development of the new table between 500 lb. per sq. in. and 1400 lb. per sq. in.)

the Knoblauch specific heats from 420 lb. per sq. in. to 1750 lb. per sq. in.[10] In days like these, steam tables must be well founded to stand the test of the next six months' work.

The Bureau of Standards data have not been extended far enough beyond those used in this development to offer any extensive check on the accuracy of the new tables. The Masaryk measurements, as shown in Dr. Havlíček's paper, are in quite good agreement with the new tables at temperatures below 800 deg. fahr at all pressures. The highest pressure comparison is somewhat misleading. Allowing for the difference in pressure of 7 atmos. between the curves compared, the agreement appears to be good even there. But the Masaryk specific heats are falling considerably below the new Knoblauch measurements above 750 deg. fahr. at 50 atmos. and 100 atmos. (700 lb. per sq. in. and 1400 lb. per sq. in.).

[6] Assistant Professor of Mechanical Engineering, Stevens Institute of Technology.

[7] Report on Progress in Steam Research at M.I.T., p. 124, this issue.

[8] Report on Progress in Steam Research at Bureau of Standards, p. 125, this issue.

[9] "Experiments on Properties of Steam at High Pressures," Dr. J. Havlíček, p. 127, this issue.

[10] "The Specific Heat of Superheated Steam," Dr. Oscar Knoblauch, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 72, no. 48, p. 1735, December 1, 1928. Abstracted on page 147 of this issue.

The Knoblauch measurements almost completely cover a large range of pressures where the properties of steam could be determined six months ago only by extrapolation of existing experimental data. The new tables represent such an extrapolation, and it is very interesting to compare specific heats computed from them with these new measurements from Germany (Fig. 7). The agreement is so good as to justify confidence in these tables, even through the range not covered by experiment at the time they were computed. It indicates a fundamental agreement between experimental results obtained at Munich by one method with those obtained at M.I.T. and Harvard by entirely different methods. The agreement between the work at Harvard, M.I.T., and the Bureau of Standards was shown by the steam-table development itself, and Fig. 7 adds another important link to this chain of experimental comparisons. The evidence at hand shows a general convergence on a well-defined grid of data that will ultimately constitute the international standard.

Correlation of Steam-Research Data

BY HARVEY N. DAVIS,[11] HOBOKEN, N. J.

MY OWN part in steam research has been confined lately to the digestion of data. The integrations which had been just started last December to secure constant total-heat lines based on a revised formulation of μ, have since been completed, largely by means of the most effective cooperation of a group of workers in Schenectady, and have been used by Professor Keenan in preparing the paper presented by him today. One weakness in the new formulation of μ has become evident, and accounts for an unexpectedly large hump in Professor Keenan's curves at the highest pressures to which the extrapolation was pushed at temperatures above 750 deg. fahr. Almost certainly no such hump exists, but the data available are not yet sufficient to show with certainty how the hump should be smoothed out, and we have decided to let it remain for the present. The effect of it on the value to engineers of the new Keenan chart and tables is believed not to be serious.

The Schenectady group have also carried through the drudgery of computing a new C_p ratio chart similar to those presented in previous progress reports, and the chart itself is now almost ready to use. The next step will be to redo the determination of a C_{p0}-curve at zero pressure from the Knoblauch data, including the data at pressures up to 110 atmospheres, which will soon be available.

In preparing this C_{p0}-curve, we propose to make full use of what we have come to call "Heck's curve." This is a curve of T_0 (at zero pressure) plotted against T_s (at saturation), each point of Heck's curve being determined by the temperatures at the two ends of a single constant enthalpy line on the pT-plane. The slope of this curve gives a relation between C_{p0} and $(dh/dT)_{sat.}$, by means of which we hope to determine C_{p0} at low temperatures from the well-known saturation total heats at correspondingly low temperatures.

Last summer I computed and plotted Heck's curve on the basis of the new μ formulation. One interesting feature of it can be reported today, namely, the position of its maximum, which locates the maximum saturation enthalpy. According to my work, this maximum saturation enthalpy occurs at about 230.2 deg. cent. or 446.4 deg. fahr., the corresponding saturation pressure being about 28.64 kg. per sq. cm. or about 407 lb. per sq. in.

The corresponding value of T_0 is about 147.81 deg. cent.

(*Continued on page 161*)

[11] President, Stevens Institute of Technology. Mem. A.S.M.E.

The Ideal Engineering Curriculum[1]

By HARVEY N. DAVIS,[2] HOBOKEN, N. J.

My conception of the educational opportunity which the undergraduate engineering schools of today would do well to offer to their students must be, by now, fairly clear to you. There will not be a multiplicity of more or less specialized undergraduate curricula, each designed to train for some one variety of engineering career. There will be one curriculum. And in this curriculum the emphasis will be placed on the basic disciplines that underlie all engineering careers; there will be plenty of mathematics, physics, and chemistry; there will be mechanics in all its branches, including the deplorably few fundamental principles that are yet known as to the nature and serviceableness of the materials of engineering.

This curriculum will also emphasize the non-technical, purely human side of an engineer's life by offering an appropriate amount of history and literature, of economics and government, of psychology, of philosophy and ethics, and even of music and art, and by stressing the economic and human sides of engineering itself in every available way.

And finally this curriculum will be such as to develop in each individual student, to at least an acceptable degree, the various arts of self-expression and of communication, including not only the sketching pencil and the drawing pen, without which so many engineers are hopelessly inarticulate, but particularly the written and the spoken word.

ANY ONE surveying the field of engineering education, and the relation thereof to the profession as actually practiced, finds himself confronted by two facts. The first of these facts is the amount and variety of specialization expected even of undergraduates, and provided for in the multiplicity of curricula or courses of study that are to be found in the catalogs of our engineering schools. You will remember that in medieval education there were the trivium of grammar, rhetoric, and logic, and the quadrivium of arithmetic, geometry, astronomy, and music, and that these seven branches of knowledge were supposed to have each its proper place in the education of every scholar. So, too, engineering, that modern, efficient, all-serving daughter of the great mother called science that is herself a thousand years younger than trivium and quadrivium—this engineering must apparently divide itself into its own trivium of civil, mechanical, and electrical disciplines; and many schools add the further quadrivium of mining and metallurgy, chemical engineering, sanitary and municipal engineering, and industrial engineering. But there is one fundamental difference. Nowadays it takes seven different scholars to compass the whole new septivium, whereas one sufficed for the old.

The Present-Day Multiplicity of Specialized Curricula

Nor is this all. In many schools, some or all of these fundamental branches of our subjects are further divided and subdivided into a maze of options from among which the engineering matriculate, or possibly his more mature brother the ripened freshman or sophomore, is expected to select that royal road best calculated to lead him directly to the goal of his ambitions and the field of his life work.

For example, one of our greatest engineering schools, while modestly confining itself to the traditional trivium of the civil, mechanical, and electrical branches, nevertheless manages, by means of options, to offer no fewer than eight separate and distinct four-year undergraduate curricula, to say nothing of five- and six-year variations of each of them. Another, with seven main branches, provides by means of options thirteen different carefully organized programs for the training of as many varieties of engineers. And still another institution, of the very highest reputation, offers seventeen main subdivisions of the field, to say nothing of eight additional apparently coequal variations of them. There are, then, according to this institution, no fewer than twenty-five different types of engineering careers, to any one of which, and to only one of which, a sophisticated youth, less than one year out of high school, may reasonably aspire. Nor is this all. A further study of this amazing catalog reveals, within many of these twenty-five major divisions, a further array of options, variations of options, and even sub-options, until, if my wavering and somewhat dazed arithmetic is correct, there are available no fewer than forty-three distinct engineering curricula, each with some freedom of election within its tabulated perfection, to say nothing of at least six—or is it eight?—carefully planned programs whereby any one of these lads may simultaneously prepare himself to save his country through the R.O.T.C.

And these are not specially selected examples; they are the first three catalogs that I happened to take out of the Stevens files. I am thinking it is about time for somebody to ask himself a few searching questions about this modern and almost universal tendency toward specialization in undergraduate engineering education. For instance, is it possible for any educational executive, committee, or faculty, however wise, to know how best to train a youth, not, mind you, for each of forty-three distinct *jobs*, but for each of forty-three distinct, all-embracing *classes* of jobs? Is it possible for any freshman, however sophisticated, to know in which of these forty-three fields his career is going to fall, or to which of them his natural aptitudes are more appropriate, or even in which of them he can hope to find in his maturer years the most personal satisfaction? And finally, even if such a freshman can be imagined to have selected unerringly his actual future career, is it by any means certain that a curriculum designed with that particular career in view, is in fact the best undergraduate training, even for that career, to say nothing of being the best for the man as a whole?

Frequency With Which Engineers Win Distinction in Fields Outside Those for Which They Were Trained

And this brings me to my second fact in the present engineering situation, namely, the frequency with which one finds an apparent contrast between the nature of the field in which an academically trained engineer has, in fact, won distinction and the label of the training that preceded and, we may hope, prepared the way for his success. Among my own acquaintances there is, for example, a man who took his degree in electrical engineering and then proceeded to win for himself a reputation in a line of work that lies in the borderland between chemical engineering and metallurgy, with scarcely a trace of electricity, or even of electrochemistry, in the whole picture. Two other graduates, one in electrical and one in mechanical engineering, are now

[1] Inaugural Address of President, Stevens Institute of Technology, Hoboken, N. J., November 23, 1928.

[2] President, Stevens Institute of Technology. Mem. A.S.M.E.

teaching various branches of industrial engineering in the very institutions that once, so carefully, selected different labels for them. A younger man, obviously destined for brilliant accomplishments in power-plant engineering, was trained and diplomaed as a boatbuilder. A graduate in mechanical engineering, who even started to teach that subject, is now the electrification expert of a great railroad. Another mechanical graduate is now in responsible charge of the installation of all the electrical equipment in a great city subway. And still another has just completed a notable bridge-building project. On the other hand, one of the most sagacious of practicing mechanical engineers and a much-sought consultant in that branch—presumably—of civil engineering which deals with the estimation and development of water powers, had an academic training that was supposed to produce a chemist.

Such cases as these could be multiplied indefinitely. Do they not indicate clearly that it makes very little difference whether our sophisticated freshman chooses wisely, or merely by drawing a slip of paper out of a hat, which one of the forty-three available disciplines he shall subject himself to? Is it not proved by such cases that almost *any* curriculum in engineering will suffice to start almost *any* thoroughly competent man on the road to success in almost *any* field, provided only that the said curriculum is thoroughly grounded on fundamental principles, and that its spirit throughout is characterized by that sincerity of mind, that instinct for analyzing every problem into its fundamental elements, that respect for facts and for reasoned judgments based on facts, and that appreciation of the art of assembling happily chosen combinations of money, materials, and men for the prosecution of activities beneficial to mankind which are of the essence of all engineering, and of many other kinds of work as well?

But, you may say, these men succeeded *in spite* of the inappropriateness of their academic training, and would have been even more successful if, by a better fortune, they could have been put through the right mill in their youth. Perhaps—and then perhaps not. Of course, there are many factors contributing to every success, the chief of which are usually such elements of character as industry, loyalty, and common-sense. But, in so far as the appropriateness or inappropriateness of their academic training affected the result at all, I am inclined to assert that these gentlemen, and their hundreds of thoroughly admirable fellow-misfits in the engineering world, have succeeded not at all in spite of but, in part at least, actually because of the apparent contrast between the type of training and the type of job that I have been emphasizing. In making this statement I am not trying to phrase a spectacular paradox. I am trying to formulate a fundamental principle of professional education that is so inherent in the trend of the times that it is being brought out in different ways by a surprisingly diverse group of observers. You will remember that Josh Billings once said, "It's fine to know a lot of things, especially if some of them are so." Similarly I might phrase the principle I am speaking of in the words, "A youngster better not know too many things, even if *all* of them are so;" in other words, there is real danger in our teaching these students of ours *too much* about the specific careers ahead of them. And why?

The Danger of Teaching Too Much

Well, only a week ago a prominent New York business man expressed to me his approval of an idea that he had treasured from a printed account of an address by a distinguished engineering teacher. Who the teacher was had escaped him, but the idea had stuck. And it was to the effect that a great captain of industry (name also forgotten) makes it an invariable rule never to use a newly employed engineering graduate on a job in the graduate's own field. If the young man has been trained as an electrical engineer, this man insists that the first job shall be of a sort commonly classified as mechanical or civil engineering, and vice versa. The reason given is that by this means the young man is forced to think for himself; his mind is kept on edge, and there is an irresistible pressure on him to work eagerly and hard, to keep on learning, to realize that his real education is not behind him but ahead, not finished but scarcely begun. In other words, this employer actually prefers the activity that is born of ignorance to the knowledge that is imparted by a specialized curriculum.

As another illustration of the principle we are discussing, namely, that it is unwise to teach too much, let me relate to the strangers in our midst an incident of which my personal friends have heard me speak all too often. The Harvard Business School offers a two-year course. In the first year all students lay the same general foundation; in the second, each selects a field of concentration from a list of six or eight options. One of these options is called Investment Banking. In the second year there is one and only one course in investment banking, and it is taught by an assistant dean of the school. About a year ago this man himself remarked in my presence to a group of distinguished visitors that something like half of the group concentrating on the option investment banking were, with his hearty approval, omitting entirely his own, and the only available, course in their selected field. One of his visitors asked why he approved of such an omission, and he replied, "For two reasons. In the first place, any one of my students who, after graduation, goes into an investment bank inevitably learns more about the details of investment banking in the first six months than I could teach him in half a dozen courses. Why should he waste his time in the school learning what he can learn far more effectively outside? Why shouldn't he devote his time in the school to learning things that he may never have another chance to learn after he is graduated? And in the second place, when one of my students goes into a bank and his boss asks him to attend to some small detail about a stock issue—a detail that he has never heard of before—what does he do? He says, 'Yes, sir,' and goes around the corner and asks the office boy and the office boy tells him. And after that has been going on a couple of weeks he forgets all about expecting to become president of the bank inside of two years, and the office boy, on the other hand, decides that the college man isn't an impossible highbrow after all, he's just a regular fellow."

And there you have our principle in a nutshell, and in its two important aspects. Why waste time in an engineering school learning details, descriptions of processes and of machines, tricks of technique of hand or brain, or even miscellaneous facts, all of which, in so far as one wants them at all, can be learned far more effectively on the job? Why not devote one's time in the school to learning what one may never have another chance to learn, namely, the fundamental principles, and how to think? And always remember that ignorance, plus willingness to learn, plus ability to learn, is a far better basis on which to establish appropriate and satisfactory human relationships with one's own organization, and with the world in general, than is "knowing a lot of things, even if *all* of them *are* so."

The Outstanding Advantages of a Single Unspecialized Curriculum

My conception of the educational opportunity which the undergraduate engineering schools of today would do well to offer to their students must be, by now, fairly clear to you. There will *not* be a multiplicity of more or less specialized undergraduate curricula, each designed to train for some one variety of engineering career. There will be *one* curriculum. And in this curriculum the emphasis will be placed on the basic

disciplines that underlie *all* engineering careers; there will be plenty of mathematics, physics, and chemistry; there will be mechanics in all its branches, including the deplorably few fundamental principles that are yet known as to the nature and serviceableness of the materials of engineering; stress will be laid on thermodynamics and in particular on the two laws of thermodynamics and on how to use them as a vital part of one's thinking; there will be electrodynamics, with emphasis on the fundamental principles of both direct- and alternating-current phenomena; at least a foundation will be laid in hydrodynamics and aerodynamics; and there will be thorough training in the various arts of mensuration, and in the still greater art of feeling instinctively the appropriate degree of skepticism as to the results. Many useful facts will be automatically stored away in the student's mind if his teachers will merely adhere strictly to the practice of basing every problem or examination question on real data. But there will be a great dearth of survey courses designed primarily to impart facts. Throughout, the method of attack, rather than the answer, will be the significant thing.

This curriculum will also emphasize the non-technical, purely human side of an engineer's life by offering an appropriate amount of history and literature, of economics and government, of psychology, of philosophy and ethics, and even of music and art, and by stressing the economic and human sides of engineering itself in every available way.

And finally this curriculum will be such as to develop in each individual student, to at least an acceptable degree, the various arts of self-expression and of communication, including not only the sketching pencil and the drawing pen, without which so many engineers are hopelessly inarticulate, but particularly the written and the spoken word. Preferably all of these arts of expression will be developed by patient, long-continued, informal, individual guidance, extending throughout the student's four years, and intimately related to the ordinary activities of his academic life, rather than by a multiplicity of special, artificial activities called plates, themes, and orations.

There will, I say, be only one unspecialized undergraduate curriculum rather than seven or seventeen or forty-three specialized ones; and the one curriculum will prepare in one sense for all sorts of engineering careers, and in another sense for no career whatever. That is, it will *not* attempt to teach the detail of any branch of engineering; but it will attempt to turn out young men who are well prepared to *begin to learn* the details of any one of many branches. Its graduates won't know much, but they will have the saving grace of knowing that they don't know much and of knowing what to do about it. If any of them fall into the hands of that captain of industry of whom I spoke a moment ago, no positions whatever will be closed to them, for wherever he puts them they will carry with them an ample abundance of the black soil of ignorance in which to raise the flower of eager self-education which he so much desires.

THE SINGLE CURRICULUM IN OTHER PROFESSIONAL SCHOOLS

In thus urging a single unspecialized curriculum, I am, you will notice, raising engineering education from the status of the trade school, with its multiplicity of special apprenticeship courses, to the status of the training schools of the older professions of law and medicine. There are corporation lawyers and criminal lawyers and patent lawyers and admiralty lawyers and a dozen other kinds of lawyers; but in no first-class law school that I am familiar with are there a dozen or even two separately labeled curricula. So also there are surgeons and obstetricians and pediatricians and psychiatrists and orthopedists and internists and specialists in the nose and throat, and even a few good old-fashioned family doctors, but every good medical school gives them all the same fundamental training. Of course, both in law schools and in medical schools the single curriculum has a certain flexibility through election by the student, and the same should be true of our ideal engineering curriculum. But the amount of election that is commonly found desirable in the schools of law and medicine is surprisingly small, especially when one considers the maturity of the students. And furthermore in law and in medicine there is intense specialization, as I have indicated above, but the student begins it, in general, only after graduation, perhaps as an interne in a hospital, perhaps in the law office where he finds his first job, perhaps, in certain cases, through highly specialized post-graduate academic study. In engineering, also, there should be opportunities of all these kinds, but they should follow rather than permeate the fundamental four years. Every engineer specializes sooner or later, and will, if he is a first-class man, specialize more and more intensely all his life. If during his undergraduate years we can lay a firm general foundation for this specialization, we shall have the most effective possible contribution to his career.

The single, broad curriculum which I have outlined is no new thing at Stevens. Throughout the fifty-seven years of its existence Stevens has stood for *one* course and *one* degree. It is true that the degree selected long ago, the degree of Mechanical Engineer, looks like a specialized degree, but every one who is familiar with what has been done during these years knows that the course has been far from correspondingly narrow, and that Stevens graduates are to be found in almost every branch of mechanical, civil, electrical, and chemical engineering, and in many less technical business and executive positions. Whether, with this ideal and with so definite a success in realizing it, Stevens has been wise in retaining an apparently specialized and really misrepresentative name for its single degree is another question. There are many who feel that a general degree in engineering would be much less likely to mislead prospective students on the one hand, and prospective employers on the other. But the weight of a long tradition is not to be lightly cast aside, and there is many an alumnus whose regret would be deep, sincere, and vociferous if his son, now with us or still to come to us, could not look forward to singing with his dad the good old song—"I'm a rambling wreck from Stevens Tech., a Mechanical Engineer."

However we may feel about the name of the degree, the essential thing is that we do the right kind of a job, and do it as well as we know how. And to the furthering of that job, the job of giving one fundamental, unspecialized undergraduate curriculum, affording what might be called a *liberal* engineering education—the job of turning out cadet engineers who, though largely untrained, are yet thoroughly prepared to train themselves through long lives of usefulness—to the furthering of that job I pledge my best endeavor.

SCIENTISTS and engineers have both been driven to appreciate to the full the vast amount of data that yet remain to be discovered and sifted and the very short time that is available for that work. And they realize, too, that if their contribution is to be of use, the temptation to range by and large over the shore must be resisted and that they must school themselves to select one pebble of one particular type only, and to work on that alone. The scope of the operations of our present-day Archimedes and Leonardos is thus perforce limited, neither can they, like Davy or Faraday, be simultaneously both physicists and chemists. They must concentrate their efforts on one branch, if they wish their labors to bring forth the most abundant fruit. They must, indeed, be content to learn as much as they can about something rather than to seek to know as much as possible, and that not a great deal, about everything.—*Engineering* (London), December 21, 1928, p. 779.

The Development of Turbo-Locomotives

Principal Advantages of Turbo-Locomotives—History of Their Development—Features and Factors Underlying Design of the More Prominent Types

By VICTOR P. DOLENGO-KOZEROVSKY,[1] CINCINNATI, OHIO

NEVER in the history of the American and European railroads have railway mechanical engineers been so active in endeavoring to improve the efficiency of motive-power units as at present.

In Europe, where the majority of the developments have taken place, this is explained by a tremendous surplus of locomotives on railroads and a bad economic situation which makes imperative the conservation of expensive fuel. The general trend is in the four following directions, ranked according to the efforts made and funds spent:

1 Improvements of piston locomotives, which are perhaps immediately more fruitful and therefore more practical
2 Diesel and turbine locomotives, so far closely rivaling one another
3 Gas and oil engines
4 Electric locomotives.

In five years, and with less than a dozen turbo-locomotives built, remarkable things have been accomplished which have proved beyond doubt that the application of the turbine and condenser to locomotive use is rational and reliable.

The turbine locomotive is only five years old, whereas its greatest rival, the internal-combustion engine, is 37 years old. The first gasoline motor car with an electric transmission was built in 1890 by the Patton Motor Car Co.

The Diesel engine at present is mounted on over fifty locomotives in the United States, while there are but nine turbine-driven locomotives in the whole world. Many fears were expressed at its first appearance, but the majority of them have been dissipated by features of the latest designs.

The principal advantages of turbo-locomotives are as follows:

1 High overall efficiency, from 14 to 22 per cent, or 1.5 to 2.5 times that of the piston locomotive
2 Continuous driving torque, resulting directly in improved adhesion
3 Smooth initial starting torque, about twice higher than that of a piston locomotive of the same power
4 Decreased cost of maintenance because of elimination of boiler washing and scaling
5 Absence of reciprocating parts
6 Reduction of roundhouse service to the inspection of couplings and piping
7 Absence of noise and smoke (the last item especially with air preheating and independent draft control)
8 Improved weight efficiency
9 Higher train speeds
10 Reduction in the weights of feedwater and fuel to be carried.

The principal disadvantages are as follows:

1 High initial cost, from 1.5 to 2 times that of the piston locomotive
2 Dependence to a certain extent upon atmospheric conditions.

A detailed study of turbo-locomotives will be found in a later section.

[1] Engineer, Cincinnati Grinders, Inc.

HISTORY OF THE TURBO-LOCOMOTIVE

The idea of applying a turbine to the locomotive drive originated in Germany in 1908, when Prosper l'Orange suggested that a turbine be placed on the tender to operate on the exhaust steam from the cylinders of an ordinary piston locomotive.

Little attention was paid to this idea at the time because of the low cost of fuel and the difficulty that had been experienced in the application of the steam turbine to the propulsion of ships.

The problems of speed reduction, variable load and speed, and reversing are fundamentally the same in both marine and railway applications. However, the locomotive drive has in addition other items of equal importance, namely, limited space and lack of a reliable cooling medium. In the case of a vessel there is always an ample supply of cooling water available, whereas the cooling medium for a locomotive is air, which has a high temperature in summertime, and is limited as to amount in tunnels.

After the Great War the extravagant waste of expensive fuel by the piston locomotive forced European railway operators to action, and as one result of their studies the turbo-locomotive was again proposed as a solution, this time to become a reality.

The brothers Frederick and Birger Ljungström, turbine and power-plant manufacturers of Stockholm, Sweden (Aktiebolaget Ljungström Angturbin), using many novel features and rather bold ideas, designed and built the first turbo-locomotive. This engine, after considerable experimental work, was placed in service on the Swedish State Railways during the winter of 1921–1922.

The usual reciprocating engines were replaced by a turbine mounted on the tender and exhausting into an air-cooled condenser, the air for combustion being preheated by means of the waste gases, the feedwater being heated by the exhaust steam from the auxiliaries, and the draft being created by a turbine-driven fan. Its maximum horsepower was 1500, its maximum drawbar pull, 30,000 lb., and its weight efficiency, 157 lb. per hp.

Almost at the same time Henry Zoelly, general manager of Escher, Wyss & Co., Zurich, set to work converting an ordinary piston locomotive into a turbo-locomotive, using, however, ideas and principles entirely different from those of the Ljungström brothers.

Both of these types proved to be successful, and most of the defects observed in actual service were eliminated in the later designs. These two locomotives made such an impression that several large concerns in Europe took up the design and construction of turbo-locomotives either along quite independent lines or under the Ljungström and Zoelly patents.

As a result, nine turbine-driven locomotives were built: four under the Ljungström patents, three embodying Zoelly's principles, and two of independent designs, one of the latter having an electrical transmission.

Many experimental locomotives are still in the process of construction and testing. Notable among these is that of Henschel & Son, Cassel, Germany. The tender of this locomotive carries a low-pressure steam turbine with a condenser. The irregular steam supply to the turbine from the cylinders, combined with the limited space available for the condenser, presents quite a problem, and several years of experimental work have not been successful in developing these principles to a practical standard.

ANALYSIS OF TYPES OF TURBO-LOCOMOTIVES

No attempt will be made here to describe the majority of the locomotives already built: only certain features and factors underlying their design will be discussed.

A—LJUNGSTRÖM LOCOMOTIVES

The first turbo-locomotive built by the Ljungströms, strange

FIG. 1 THE SECOND 1800-HP. LJUNGSTRÖM TURBO-LOCOMOTIVE—BUILT FOR THE SWEDISH STATE RAILWAYS

Diameter of drivers, 5 ft.
Steam pressure, 280 lb. per sq. in.
Grate area, 33 sq. ft.
Heating surfaces:
Firebox, 127 sq. ft.
Tubes, 1186 sq. ft.
Total, 1307 sq. ft.
Superheater, 785 sq. ft.
Air preheater, 8600 sq. ft.
Cooling surface of condenser, 12,900 sq. ft.
Weight in working order, 316,000 lb.
Weight on drivers, 110,000 lb.
Weight of material, 264,000 lb.
Coal capacity, 17,700 lb.
Maximum speed, 56 m.p.h.
Tractive effort, 32,800 lb.
Maximum rating at rail, 1800 hp.
Gage, 4 ft. 8½ in.
Total wheelbase of locomotive and tender, 60 ft. 8½ in.

as it may seem, still occupies a prominent place among its younger colleagues. A complete description of this engine was published in *Engineering* (London), July 21, and August 4, 11, and 18, 1922, and in the *Railway Mechanical Engineer* of October and November of the same year.

This locomotive was submitted to extensive tests in the shops and in actual service, and the results thus obtained gave valuable information for the design of the next three locomotives, namely, one for the Swedish State Railways (Fig. 1), another for the Argentine State Railways (Fig. 2), and a third for the London, Midland, and Scottish Railways.

In general, the problem of building locomotives on a production basis by a concern specialized and equipped for the manufacturing of turbines and power-plant equipment is of a rather difficult nature, and therefore combinations of locomotive and turbine manufacturers were formed. Nydqvist & Holm in Sweden and the Beyer, Peacock & Co., Ltd., in England are at present building commercial turbo-locomotives under the Ljungström patents, the turbines and some of the locomotive equipment being supplied by the Ljungström works.

A similar combination, which will be referred to later, was formed by Friedrich Krupp in Germany and Escher, Wyss & Co. in Switzerland. These combinations are of much the same nature as the General Electric-American Locomotive Co. and the Westinghouse Electric-Baldwin Locomotive Works arrangements for the production of electric locomotives. As may be seen from Table 1, the distinct features of the Ljungström locomotives are a single turbine, good distribution of weight, and a good weight efficiency.

The turbine, which is of the impulse-reaction type, has an unusually large number of rows of blades which give it almost constant efficiency over a great range of speed. This feature enables the engine to work economically under variable service conditions, whether hauling freight or passenger trains, as was shown by curves of the coal consumption of turbine and reciprocating locomotives at different speeds in the *Railway Mechanical Engineer* of November, 1922, p. 627.

As a rule, the turbine is very uneconomical at slow speeds, and the economy of the Ljungström locomotive is below that of a reciprocating locomotive of the same power at a speed below 4 miles per hour. Another important feature of the Ljungström turbine is the rapid rise of the horsepower curve or the decline of the tractive-effort curve as the speed increases. To quote from the articles in *Engineering:*

> This is a useful characteristic in a locomotive as it tends to prevent the spinning of the driving wheels at starting when the rails are slippery. The driver has thus a greater measure of control over the engine both at the start and when pulling hard on gradients.

TABLE 1 DATA ON TURBO-LOCOMOTIVES

Year	Builder and railroad	Rated tractive force, lb.	Wheel arrangements and weights in working order, lb. Total engine	Total tender	On drivers	Type of turbine	Steam pressure, lb. per sq. in.	Type of condenser and cooling surface (sq. ft.)	Rated hp. and max. speed, m.p.h.	Weight efficiency lb. per hp. Engine	Engine and tender
1921–22	Aktiebolaget Ljungström Anturbin; Stockholm, Sweden; Swedish State Railways (*a*)	30,240	138,880 4-6	143,360 (Driver) 6-2	107,520	Ljungström axial-flow impulse reaction 2-15	285	Air-cooled 10,764	1800 68.3	80 (Tender)	156.7
1921–22	Swiss Loco. Works and Escher, Wyss & Co.; Zurich, Switzerland; Swiss State Railways	25,000	130,000 (Driver) 4-6	90,000 (Approx) 4-4	91,200	Zoelly 6-stage impulse	200	Water-cooled	1000 47	130	220
1922	Sir W. G. Armstrong, Whitworth & Co. (Ramsay) Scotswood, England; London, Midland & Scottish Railways	22,000	293,000 (Driver) 2-6	6-2	90,000 (Approx.)	Ramsay 9-stage impulse	200	Water film evaporative	1100 60		267
1923–27	Friedrich Krupp, Essen, Germany; German State Railways	41,000	224,800 (Driver) 4-6-2	135,000 4-4	120,000	Zoelly 6-stage impulse	220	Water-cooled	2000 62.3	112.4	179.6
1925	Beyer, Peacock & Co., Ltd., Manchester, England; London, Midland & Scottish Railways	38,000	4-6	(Driver) 6-4			285	Air-cooled	2000		
1925	North British Locomotive Co., Ltd., Glasgow, Scotland (Reid-MacLeod); L. M. & S. Ry.	15,000	4-4	4-4 (Driver)		4-stage impulse	200	Water-cooled	1000 60		
1926	J. A. Maffei, Munich, Germany; German State Railways (*b*)	35,000 (Approx.)	230,000 (Driver) 4-6-2	150,000 4-4	132,000	Maffei impulse-react. 3-5	324	Water-cooled 2370	2500 78	92	152
1926	Nydqvist & Holm, Trollhättan, Sweden; Swedish State Railways	32,800	148,000 4-6	168,000 (Driver) 6-4	110,000		280	Air-cooled 12,900	1800 56	93.3 (Tender)	176
1926	Nydqvist & Holm; Argentine State Railways	33,000	127,000 4-6	138,000 (Driver) 8-2	115,000		280	Air-cooled 12,900	1750 40.5	79 (Tender)	151.5

(*a*) Per cent of heat at crankpin, 14.7. (*b*) Per cent of heat at crankpin, 15.6.

The condenser (old type) itself presents an unusual feature: namely, the plant requires no surplus water whatever, apart from that required to make up for boiler leakage and that used for heating and whistle steam, etc. An average of the test data shows the water requirement to be 2 cu. m. per 500 km. (170 gal. per 100 miles), a saving of 95 per cent. This fact is of especial importance, as in the particular service of this locomotive across the Argentine desert it is calculated that the saving in water freight alone would amount to $75,000 a year.

The last three locomotives, besides embodying many improvements and refinements over the first one, are provided with two whirling blasts of highly preheated air over the fire bed. The first locomotive smoked considerably, but the latest types are practically smokeless, cinderless, and noiseless.

B—Krupp-Zoelly Locomotives

In general, in all designs the choice of the condenser determines the arrangement of the turbine and auxiliaries. All of the German locomotives employ the water-cooled surface condenser. This system offers the disadvantage of having both a condenser and a recooler for the condenser cooling water. The condenser is very small as compared with one of the air-cooled surface type. The coefficient of the heat transmission from steam to water is about 500 B.t.u. per deg. fahr. per sq. ft. per hour, whereas for an air-cooled condenser of the Ljungström type it is about 25 B.t.u. for an air velocity of 4000 ft. per min.

Comparing the condenser surfaces, the Maffei type is only 7 times smaller than the Ljungström type. This low ratio is explained by the direct ultimate contact of the reserve feedwater

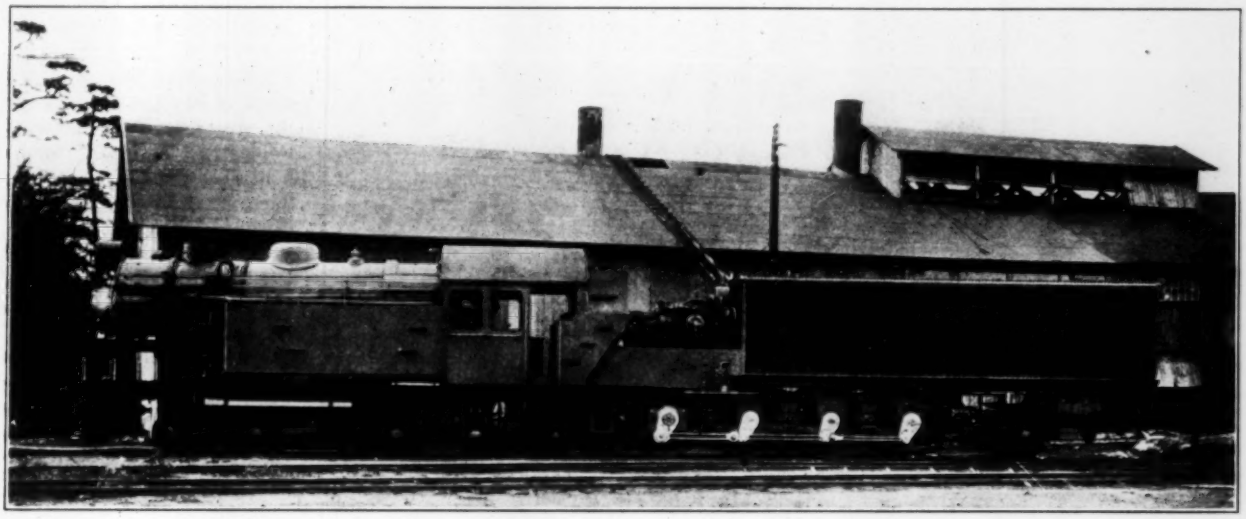

FIG. 2 1750-HP. LJUNGSTRÖM TURBO-LOCOMOTIVE BUILT FOR THE ARGENTINE STATE RAILWAYS

Diameter of drivers, 4 ft. 10 in.
Steam pressure, 280 lb. per sq. in.
Grate area, 30 sq. ft.
Heating surfaces:
Firebox, 126 sq. ft.
Tubes, 950 sq. ft.
Total, 1076 sq. ft.
Superheater, 615 sq. ft.
Air preheater, 8600 sq. ft.
Cooling surface of condenser, 12,900 sq. ft.
Weight in working order, 265,000 lb.
Weight on drivers, 115,000 lb.
Weight of material, 232,000 lb.
Oil capacity, 14,300 lb.
Maximum speed, 40.5 m.p.h.
Tractive effort, 33,000 lb.
Maximum rating at rail, 1750 hp.
Gage, 3 ft. 3½ in.
Total wheelbase of locomotive and tender, 54 ft. 5½ in.

The disadvantages of the Ljungström system are: the location of fuel (not so pronounced with liquid fuels); the high power required for driving the condenser fans, as an enormous volume of cooling air is required—4500 cu. ft. per sec.; and the flexible live-steam connection between the boiler and tender units. However, provisions of an ingenious character were made and, it is claimed, no trouble was experienced with the latter part.

To conclude this discussion, mention should be made of the very carefully developed preheating system for both feedwater and combustion air, the latter being the first to be installed on locomotives. Quoting again from *Engineering:*

> The Ljungström locomotive does not depend by any means for its efficiency entirely upon the greater heat drop it utilizes. The employment of the otherwise waste heat of the flue gases to heat the air for combustion results in an increase in the firebox temperature and furnace efficiency.

The last engine built for Argentina, being equipped with all these auxiliaries, has the best known combined weight efficiency for a steam locomotive. The average fuel consumption is 22 lb. of oil per 1000 ton-miles. The average vacuum maintained is 16 in. of mercury at 100 deg. fahr. air temperature, and 22 in. at 88 deg. fahr. The large quantity of distilled water in the condenser acts as a cold reservoir for relatively short overloads.

in the tender with the exhaust steam from the turbine of the Ljungström locomotive.

Owing to its bulk, the recooler must be placed on the tender. As it is not desirable to have flexible steam or vacuum connections the turbine and the condenser are mounted on the boiler unit. Now, due to the limitations of breadth and rigid wheelbase, not much space is available for auxiliaries and means for reversing the engine. The marine-turbine arrangement, where two turbines, one for ahead and another for astern propulsion, are placed on the same shaft, was applied to the locomotive drive. Thus great simplicity of construction and a compact arrangement were attained at the expense of decreased power when running backward.

This location of units offers greater possibilities for the use of high steam pressure and consequently for the design of more powerful engines, although the engineman is not able to watch the performance of the turbine as conveniently as in the Ljungström system.

Another objection to the powerful turbo-locomotive is that the power is transmitted by a single crankpin. In the case of reciprocating locomotives, one side rod seldom drives more than two pairs of drivers, whereas the side rod of the Krupp-Zoelly engine always drives at least three pairs. Also, it is generally recognized that on large engines the limit of power transmission

through a single crankpin is almost reached. In the United States, recourse to the three-cylinder engine, and the once extensively used Mallet type seem to be possible solutions.

The turbo-tender of Henschel & Son, if developed to railroad requirements, will solve the crankpin problem and will find a broad field of application.

A description of the first turbo-locomotive of the Zoelly type converted from a standard 2-6-type Swiss engine by Escher, Wyss & Co. and the Swiss Locomotive Works, was published in Trans. A.S.M.E. for 1924.[2]

Due to limitations in regard to changes that could be made, the locomotive was not very successful and gave a rather bad impression. Its greatest defects were a poor weight efficiency and an unsatisfactory recooler.

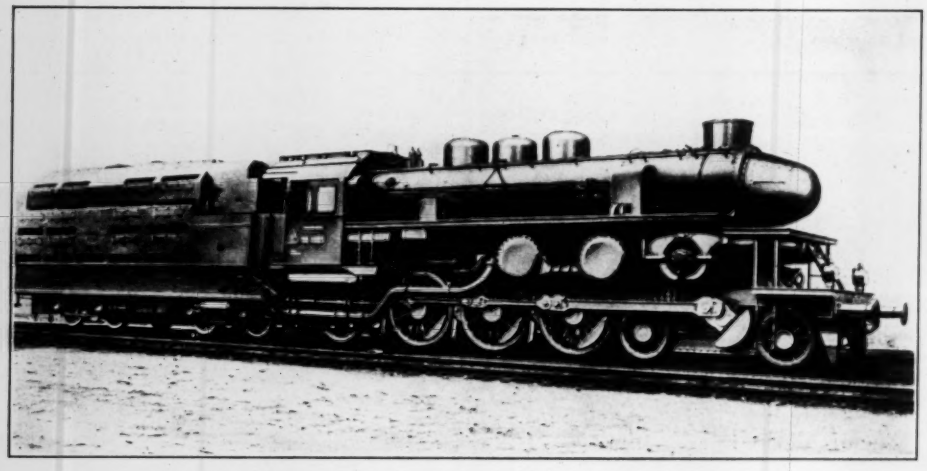

FIG. 3 THE FIRST 2000-HP. KRUPP-ZOELLY TURBO-LOCOMOTIVE

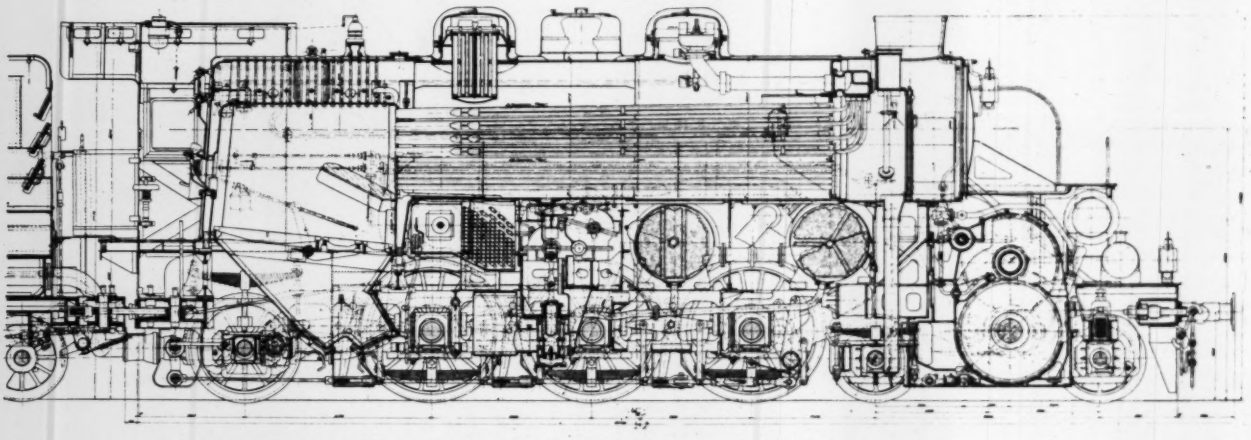

FIG. 4 SECTIONAL VIEW OF THE 2000-HP. KRUPP-ZOELLY TURBO-LOCOMOTIVE SHOWN IN FIG. 3

At the same time, Friedrich Krupp, independently of Zoelly, developed a cooler of the sprinkler-system type, in which the fan no longer forced the air through the cooling compartments, but sucked it through instead. Later, Krupp and Escher, Wyss & Co. formed a corporation in which the latter supplied the turbines and some of the equipment, and the former the remainder of the engine.

The same basic ideas were used in the building of a 2000-hp. Krupp-Zoelly engine (Figs. 3 and 4). A complete description of this locomotive was published in the *Kruppsche Monatshefte*, August and September, 1924.

After the first tests this engine was considerably changed, but not until February 8, 1927, were the acceptance tests by the German State Railways begun.

The limitations as to maximum wheelbase (19.5 meters) imposed by the German State Railway Administration caused a crowding of the auxiliaries, and some of them had to be discarded because of lack of space.

An ingenious feature which enables the engine to maintain its rated speed on heavy grades, and which gives a rapid acceleration, is its auxiliary overload valve by which the horsepower of the main turbine can be increased from a normal of 2000 to a maximum of 2800. The rated speed of the turbine, 6800 r.p.m., corresponds to a train speed of 50 miles per hour, and the steam consumption of the locomotive is 18,000 lb. per hour when developing 2000 i.hp. Such overload valves are now used on all German designs.

The weight efficiency calculated on the basis of 2800 hp. gives the astonishing figure of 129 lb. per hp.

Another interesting device on this engine is the auxiliary boiler which is used as an evaporator for replenishing the leakage water for the main boiler, for the heating system, or as a vacuum evaporator. In the latter case the boiler, being directly connected to the condenser, has the condenser pressure.

The flue gases are used for the feedwater preheating, thus reducing their volume and considerably decreasing the power required for driving the draft fan. The principle is exactly the same as in the Ljungström system, except for the use of an economizer instead of an air-preheater. The water is preheated to 130–140 deg. cent. (266–284 deg. fahr.), the rate of flow given above.

The principal facts in regard to the performance of the Krupp-Zoelly type are:[3]

[2] "The Zoelly Turbine-Driven Locomotive," by H. Zoelly. Trans. A.S.M.E., vol. 46 (1924), p. 1205.

[3] Dr. Rudolf Lorenz, Essen, Germany, in "Eisenbahnwesen."

1 A portion of the water passing through the sprinklers evaporates, which results in a water consumption approximately equal to about one-half of that of a piston locomotive of the same capacity;

2 As the passage of heat is effected almost exclusively through the evaporation of this water, a recooling plant on the Krupp-Zoelly system is practically independent of the outside temperature;

3 For the same reasons the air consumption in the sprinkler-cooler is very small; hence the power required for shifting this air through the condenser is likewise small.

The service time for this type of locomotive was assumed as 16 hours per day, which may seem unusual at the first glance, but —to quote Dr. Lorenz—"when it is remembered that with the exception of the axle and driving-rod bearing the entire lubrication is automatic and that the boiler need neither be blown off nor the sludge be removed, a high-grade locomotive of this type may well be utilized as mentioned above provided that the schedule is arranged accordingly." The importance of the service time per day has been mentioned previously.

The initial cost, not including the development cost, is given as 1.8 times that of a reciprocating locomotive of equal capacity and equipment. It is estimated that on the German railroads the extra cost will be amortized by the saving effected in $3^1/_2$ to 4 years, and that the total saving effected in 9 further years should be about twice the initial cost.

C—The J. A. Maffei Turbo-Locomotive

This type (Figs. 5 and 6) cannot properly be classified under the Krupp-Zoelly group, since, although similar in general arrangement, it differs considerably in details, especially in the recooler. It was described in *Zeitschrift der Vereines deutscher Ingenieure*, No. 47, 1926, and in the *Railway Mechanical Engineer*, February, 1927.

So far the Maffei engine is the most powerful engine of its class. The heat of the waste gases of combustion is not utilized either for water or for air preheating. Hence the power required to run the draft fan is high. Notwithstanding these facts, the percentage of the heat converted into useful work by the turbine is equal to 15.6 (based on the heat content of the fuel), the rated speed being 43.5 miles per hour and the air temperature 80 deg. fahr.

The distinct difference of the Maffei turbine arrangement from that of Krupp's is the improved distribution of weights and stresses.

The pinions of the geared transmission are subjected to torque stresses only, and the turbine and intermediate shafts are not subjected to any bending moment.

A spring drive is provided between the rim and the boss of the intermediate shafts which transmits the total force. In its appearance it resembles the usual spring drive of an electric freight locomotive.

The draft fan is driven by a two-stage impulse turbine of simple but very rigid design, as the impeller which works under very severe stresses is keyed directly to the turbine shaft. The Curtiss wheel is mounted on a disk which is forged in one piece with the shaft.

Another peculiar feature to be found in this locomotive is the oil-cooling arrangement which is located at the front of the engine.

Although the experimental stage was passed long ago and the locomotive was accepted by the German State Railways on March 14, 1927, no data on actual performance have as yet been published.

The engine, however, is now in the regular express-train service between Munich and Augsburg, Bavaria.

D—British Developments

English efforts to develop a satisfactory turbo-locomotive in the past five years have apparently not yielded any significant results. Two turbo-locomotives have been built and, after the various revisions suggested by extensive tests, finally put into operation. The published performance data and descriptions are very satisfactory, but a slight analysis shows immediately numerous objectionable features of design that cannot be easily improved.

1 *The Ramsay Turbo-Electric Locomotive.* Excessive weight, inconvenient location of units, necessitating a flexible connection of the large vacuum pipe between the boiler and tender platforms, high initial cost, and possibly a low overall efficiency on account of absence of air and feedwater preheaters, are the principal reasons for the failure of this type of turbo-locomotive.

The weight efficiency of the Ramsay locomotive is equal to that of one equipped with the Diesel engine. This fact may be explained by the complicated electrical control and the electrical transmission used.

From the railway operating point of view, its performance is identical with that of the electric locomotive, with the difference that while the electric locomotive has an ample supply of energy available from a large power plant, the Ramsay engine is limited by the capacity of its boiler.

As shown by the data, the decrease of the tractive effort with an increase in speed is very small. This characteristic, as explained before, is undesirable for locomotives. The rated tractive effort is exerted up to a speed of 15 miles per hour as compared with 75 per cent of that for the Ljungström and 87 per cent of that for the Krupp-Zoelly locomotives.

The motors used are of the axle-hung type, which is the simplest and most rugged for slow-speed service, but for a speed of 60 miles per hour, to quote R. Eksergian of the Baldwin Locomotive Works:

> Due to the relatively high r.p.m. obtained by the gear ratio for slow-speed service a simple and compact motor is possible. For high speed this type is not adaptable, since with the lower gear ratio needed and the consequent higher torque demand on the motor at low speeds, the motor-frame size becomes excessive for the limited space between the drivers in large-size locomotives. In addition, the unsprung weight, the stresses at high speeds, etc., offer serious difficulties for high speeds.

The most interesting feature of the Ramsay locomotive is its condenser. The principle involved offers another solution for carrying off the heat in condensing locomotives. This condenser consists of a drum, the shell of which is formed by the condenser tubes. This drum revolves on its axis, the lower portion dipping into the cooling water, which is carried along by the tubes and evaporates upon them.

A description of the Ramsay locomotive was published in the *Railway Mechanical Engineer*, January, 1925.

2 *The Reid-MacLeod Geared Turbine Locomotive.* A very general description of this engine appeared in *Railway and Locomotive Engineering*, April, 1927. It is a rigid-frame, two-truck locomotive having the condenser in front and the boiler in the rear. The locomotive is equipped with high- and low-pressure turbines mounted on the trucks and supported by means of springs. The reduction is obtained through helical gears and a pair of ordinary bevel gears. Because of the limited space, very few provisions were made to render the drive flexible. As a result, the maintenance cost will be high.

The location of turbines makes difficult their inspection and repair. A slight repair will take the engine out of service for a considerable time.

The high water consumption in both the boiler and condenser necessitates a large water tank.

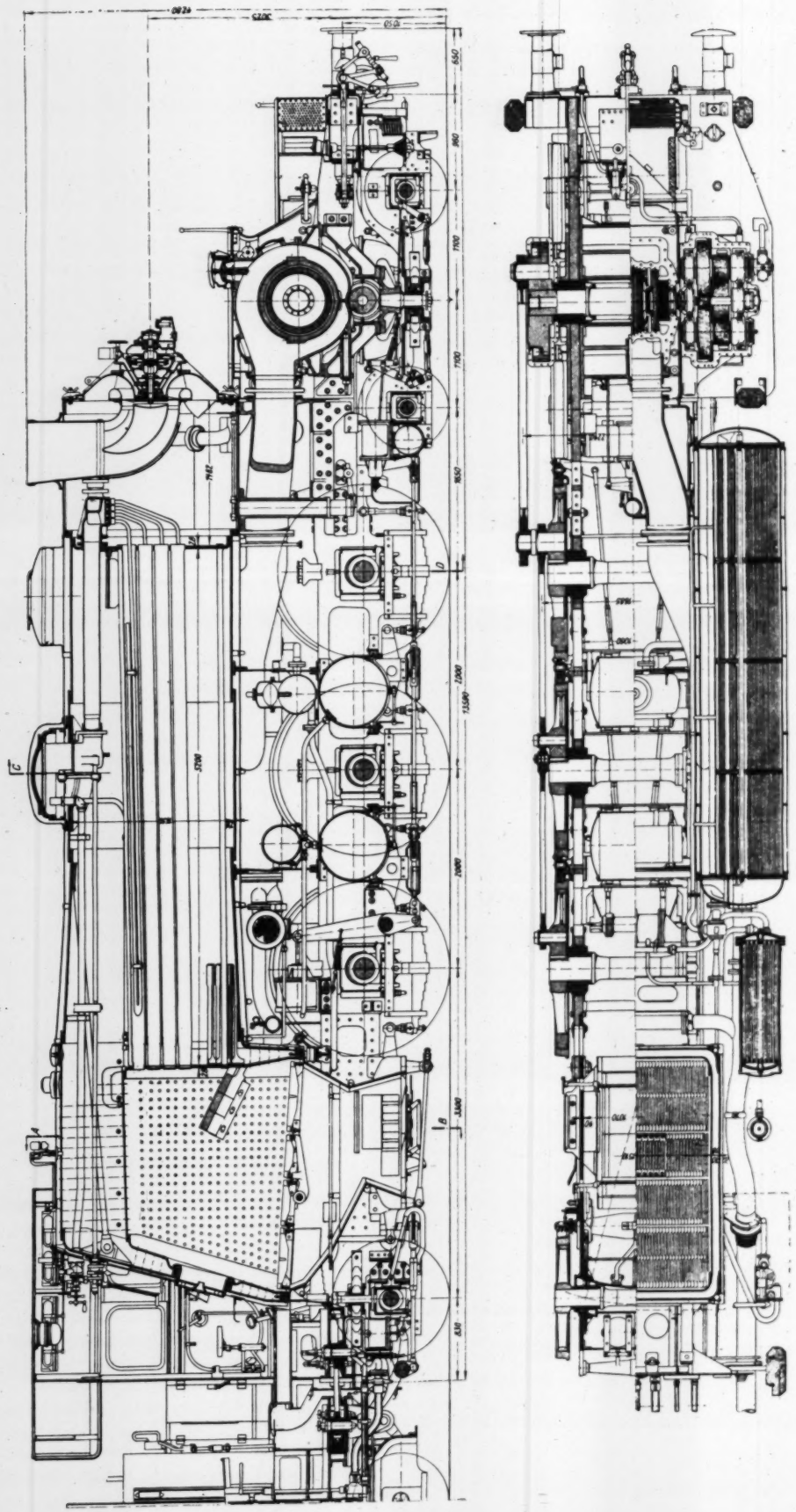

FIG. 5 SECTIONAL VIEWS OF 2500-HP. J. A. MAFFEI TURBO-LOCOMOTIVE BUILT FOR THE GERMAN STATE RAILWAYS

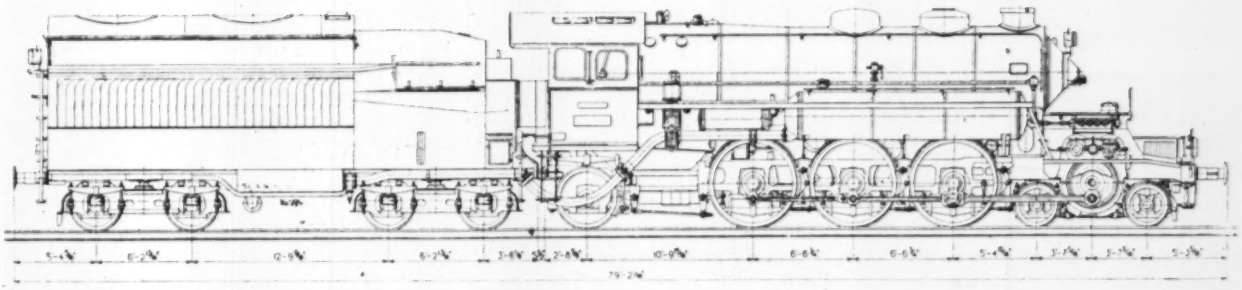

FIG. 6 2500-HP. J. A. MAFFEI TURBO-LOCOMOTIVE WITH TENDER

Steam pressure, 313 lb. per sq. in.
Diameter of drivers, 5 ft. 8⅞ in.
Average tractive power, 24,250 lb.
Heating surfaces:
Firebox, 140 sq. ft.
Tubes, 1578 sq. ft.
Superheater, 549 sq. ft.
Total in contact with fire, 2267 sq. ft.

Grate area, 37.7 sq. ft.
Weight empty, 93.5 tons
Adhesion weight, 59 tons
Weight in working order, 102.6 tons
Total wheelbase, 36 ft. 7 in.
Gage, 4 ft. 8½ in.

Tender
Cooling water, 4400 gal.
Feedwater, 946 gal.
Capacity of coal bunker, 6 tons
Weight empty, 36.5 tons
Weight in working order, 67 tons
Total wheelbase, 24 ft. 15⁹/₁₆ in.
Total wheelbase, of locomotive with tender, 68 ft. 6½ in.

Nothing as yet can be said concerning price, weight efficiency, and performance.

POSSIBILITIES OF FUTURE DEVELOPMENT OF TURBO-LOCOMOTIVES

The desire to obtain a more efficient utilization of the energy in the fuel introduced the turbine into the railroad field.

In addition to recovering the heat in the flue gases, perfecting mechanical devices, and bleeding the turbine for feedwater preheating, the efficiency of the condensing cycle could be further improved thermodynamically by:

1 Increasing the vacuum
2 Increasing the temperature of the superheated steam, and by
3 Increasing the steam pressure.

Increasing the vacuum will require a larger recooler in the Krupp-Zoelly system and a larger condenser in case of the Ljungström system. Even if the space limitations could be disregarded, the gain in the vacuum would be offset by the increased power required to drive the cooling fans for the enlarged condenser or recooler.

Increasing the temperature of the superheat would require more stages in the turbine, as for the best condenser performance the exhaust steam from the turbine should enter it in a saturated state. This, perhaps, could be accomplished in a reaction turbine of the Ljungström type.

However, an increase in superheat temperature, together with an increase in pressure, will give the desired results combined with the minimum of complications. Under these conditions a two-stage reheating cycle will yield an appreciable gain in the efficiency.

At 900 lb. (60 atmos.) pressure and 250 deg. fahr. superheat, the temperature of the steam is 784 deg. fahr., which is only 146 deg. more than the temperature of 200-lb. steam with the same superheat.

It seems likely that the difficulties arising from such increases in temperature as are entailed by the use of steam of 900 lb. pressure can ultimately be overcome. The special problems which arise in locomotive practice due to the conditions peculiar to stationary power-plant service are being vigorously attacked. They appear to offer no insurmountable difficulties.[4]

No restrictions will be caused by the turbine end, as such turbines need have only a reasonable number of stages.

Escher, Wyss & Co. are supplying the Siemens-Schuckertwerke with a turbine designed for a nozzle pressure of 2500 lb. for the power plant at Siemensstadt, Berlin, operating the steam boilers at the critical pressure.

In locomotives for such high pressures the advantages to be gained by condensation are of secondary importance. Still it will be necessary to retain the condensation under all circumstances because super-pressure boilers with narrow tubes depend upon the condensing water for feeding.

Whether in such super-pressure locomotives it will be necessary to attain the highest possible vacuum or whether the lowest vacuum required for condensing the steam will suffice, is a question which need not be discussed at present.[5]

The advantages of high pressures and of the so-called Benson cycle are set forth in *Power*, May 22 and 29, 1923.

The temperature to which it is necessary to raise water before it can be evaporated into steam depends upon the pressure. For every given pressure there is a corresponding minimum temperature at which steam can exist. Steam existing at this temperature is said to be saturated, and any reduction in temperature will cause some of the steam to be condensed into water. Conversely, any increase in pressure at a given temperature will cause some of the steam to condense.

The critical temperature is that temperature above which no pressure, however great, is sufficient to cause the vapor to liquefy. In other words, above the critical temperature, the substance permanently assumes the vapor state. The critical pressure (approximately 3200 lb. per sq. in.) may be defined as the vapor pressure of water just at the critical temperature (709 deg. fahr.). The density of the water is equal to the density of the steam at the critical point, and there is no physical difference between the two states, water and steam, at that point. Thus, if water be heated up to the critical temperature while at the critical pressure, it changes suddenly into steam without further application of the so-called latent heat.[6]

The question of maintaining high pressure on turbo-locomotives is of secondary importance, because the engine output is independent of the boiler performance.

By regulating the draft fan the fireman can increase the development of steam at will, and can prevent the boiler pressure being too low just when the maximum capacity of the engine is demanded.[5]

The use of the Benson principle, together with reheating and regenerating processes, will limit the efficiency obtainable with the steam locomotive.

TURBO-LOCOMOTIVES PROPOSED AND UNDER CONSTRUCTION

In order to illustrate the possibilities of high-pressure locomotives employing the turbine as a prime mover, the following brief

[4] "The Use of High Steam Pressure in Locomotives," E. C. Schmidt, MECHANICAL ENGINEERING, vol. 48, Mid-November, 1926, p. 1195.

[5] Dr. R. Lorenz in *Kruppsche Monatshefte*, November, 1924.

[6] W. J. Kearton in "The Steam Turbine: Theory and Practice."

description of several engines proposed and under construction is given.

Firms in nine countries operating under the Ljungström patents have proposed a great variety of turbo-locomotives. The data on these given in Table 1 are self-explanatory.

The Krupp-Zoelly corporation have projects for two locomotives to operate on 40 and 60 atmos. boiler pressure, respectively.

The boiler for the 4-6-4-type locomotive (Fig. 7) is designed for a steam pressure of 40 atmos. or about 600 lb. per sq. in. abs. It is of the fire-tube type with a regular staybolt-supported firebox.

The induced-draft fan and the economizer are located in line with the boiler.

As in the previous designs, fore-and-aft impulse turbines on the same shaft are employed. The weight of the reduction unit and of the turbines is carried partly by the drivers, thus increasing the adhesive weight.

In general, the same arrangement as that on the 2000-hp. engine is used, with the addition of an air preheater which is located directly back of the economizer, the tubes being placed longitudinally across the boiler.

The 4-8-2-type locomotive (Fig. 8) is designed for a steam pressure of 60 atmos. or about 900 lb. per sq. in. abs. The boiler is of the water-tube type. The grates are located between the two lower drums, and the two upper drums are isolated from the fire bed by the water tubes of the two lower drums. An economizer and air preheater are located in the fore part of the engine.

The impulse-reaction turbines used have a considerable number of stages in order to keep the peripheral velocity low, and have the exhaust steam from the turbine in a saturated state. A single turbine of the reaction type would probably suit the best, the reversing of the engine being performed by a reverse gearing. In this design, however, two shafts, each having one ahead and one astern turbine, are placed across the engine. Thus the drive is performed by several pinions, resulting in an improved distribution of stresses in the gearing.

The locomotive unit weighs 141 tons, 84 tons being placed on the drivers. Hence the tractive effort, with a coefficient of adhesion of 0.25, is about 42,000 lb.

It is of interest to note that the idler-shaft center is higher than the center line of the drivers, so that an intermediate idler shaft has to be used.

Probably the most interesting turbo-locomotive is one being developed by the firm of J. A. Maffei, Munich, the design of which was approved by the German State Railways, and on which actual construction was begun last June.

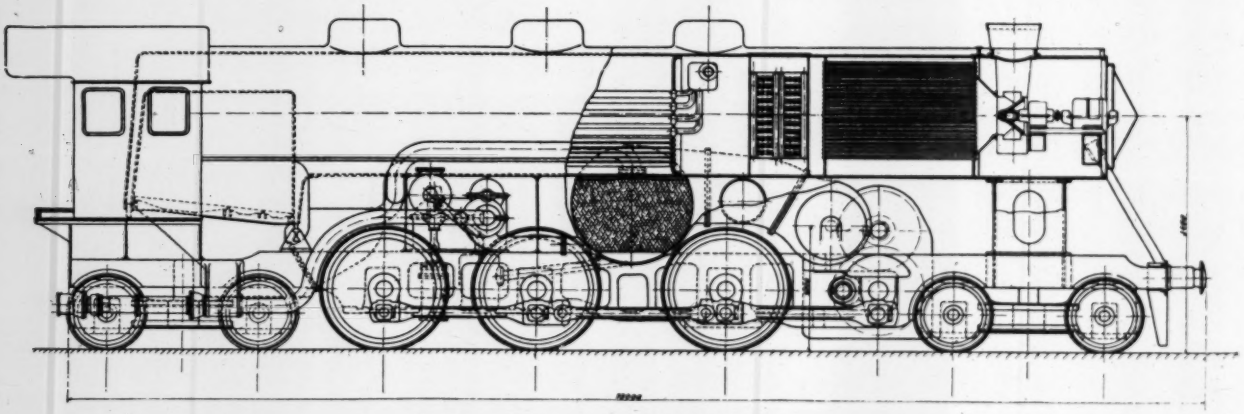

FIG. 7 KRUPP-ZOELLY 4-6-4 TYPE TURBO-LOCOMOTIVE

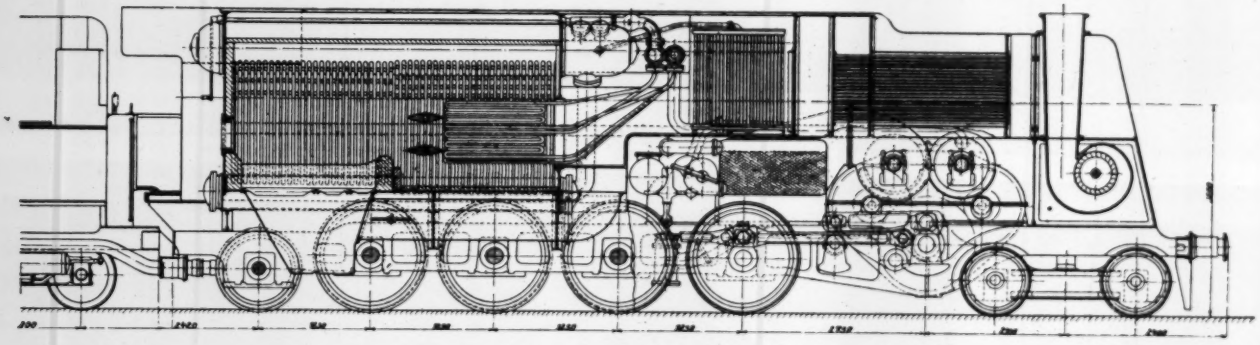

FIG. 8 KRUPP-ZOELLY 4-8-2 TYPE TURBO-LOCOMOTIVE

This locomotive is of the 4-6-2-type, and is rated at 2000 hp. normal and 2500 hp. maximum. The arrangement of units is the same as in the Krupp-Zoelly system.

Due to the relatively small space required and the adaptability of the fluctuating loads, the Benson boiler was selected from the various designs of high-pressure boilers.

As the Benson boiler has no steam-storage capacity, a special auxiliary boiler is provided. The arrangement of the generating and storage boilers is as follows: The Benson boiler, being a system of tubes working parallel in groups, forms the firebox; in front of it is placed a short locomotive boiler of standard design which serves not only as a storage boiler but also as a feedwater preheater and to a certain extent as a steam generator.

The induced draft for the combustion is produced by a compact high-speed blower placed at the front of the locomotive. The prime mover, consisting of one high-pressure and one low-pressure turbine, is mounted on the forward truck and transmits its power

through a double-reduction gearing to a jackshaft with cranks to the drivers.

The reversing of the locomotive is obtained by a reverse gear instead of a separate astern turbine.

The steam from the turbines is exhausted into two water-cooled surface condensers operating in parallel. The circulating condenser water is cooled in the usual way in a recooler placed on the tender.

The condensate, storage, and high-pressure feedwater pumps are arranged in one unit and are driven by a high-speed steam turbine through a suitable reduction.

The ventilating fans of the recooler and the cooling-water circulating pump are driven by another steam turbine placed on the tender.

The cycle of the system is as follows: The high-pressure feed pump delivers the feedwater under a pressure of 3300 lb. per sq. in. into the Benson boiler, where it is heated to 734 deg. fahr.; a throttle valve reduces the pressure of the steam thus formed to 2650 lb. per sq. in. and then its temperature is raised to 797 deg. fahr. in the adjoining superheater. This steam is led into the high-pressure turbine to work, and before entering the second portion of that turbine is reheated to 720 deg. fahr. in an intermediate superheater. From the high-pressure turbine the steam is sent to the low-pressure turbine, and finally rejected to the condensers.

The bled steam from the high-pressure turbine is used for the auxiliaries, which exhaust either to the feedwater preheaters or to the low-pressure turbine as conditions may demand.

The overall efficiency is expected to be 16 per cent, or 19.5 per cent based on the output of the turbine at the crankshaft.

The latest project worthy of mention is that of Henschel & Son, namely, a 2000-hp. tank-type, rigid-frame turbo-locomotive with a condenser of original design; nothing, however, is as yet known about it.

The Moir-Buchanan Process of Concrete-Pipe Manufacture

THIS process is a combination of centrifugal and mechanical action. The spinning is done at a relatively low speed, too low to separate the aggregates but high enough to give a good packing effect. Additional density is obtained by compacting the shell by means of a combination knife and trowel. The machine used is essentially a lathe and gives positive drive to the mold. The concrete mix is introduced into the mold during the spinning process by means of a bucket semicircular in section and of the same length as the pipe to be cast. This bucket is provided with a blade or knife along its entire length which gives the troweling effect. It is fixed eccentrically on a revolving mechanism so that when carrying and charging it is quite clear of the mold and the material dumped. When it is turned in the opposite direction to that of dumping, the blade, owing to eccentric setting, is brought into contact with the concrete dumped and troweling is effected. It is not necessary to measure the charge since any excess material is cut off by the blade and drops back into the bucket. The shell is dense and of uniform structure throughout; because of the troweling action it is trimmed to gage and the interior of the pipe is given a perfectly true and polished surface. It is stated that several plants are already in operation in this country and abroad.

In connection with this process is used the Bille-Ligonnet method of lining the concrete pipe with asphalt. Asphalt does not adhere well to concrete, but it was found that if such an intermediary as clean, hard stones, clinkers, slag, or coke is embedded in the surface of the concrete, a satisfactory joint is made. Green concrete will bond firmly to the stones if both are hot when they are joined. After the concrete shell has been spun and troweled to the proper density, a charge of sharp stones to form the binder is introduced into the mold, which is then spun at a speed sufficient to embed the stones about half their length into the concrete shell. This requires only a few minutes. The pipe is then cured and thoroughly cleaned, the projecting stones are heated by means of a hot air blast or gas flame, and the molds spun on a simple spinning machine, whereupon a sufficient amount of molten asphalt is poured in. The pipe is spun until it is practically set, at which time cold water is introduced to accelerate the rate of cooling. (W. H. Farrand in *Hydraulic Engineering*, vol. 4, no. 11, Nov., 1928, pp. 662–663, illustrated, *d*)

New Boilers for Old

AT THE Franklin Sugar Refining Company's power plant in Philadelphia, Pa., until recently there were installed in the boiler plant 48 horizontal water-tube boilers each of 250 hp. capacity. Not only did this equipment crowd the building space it occupied to the point where additional capacity could not be installed, but it was insufficient to carry the load. The 48 boilers have now been replaced by five Stirling boilers, each having 10,210 sq. ft. of heating surface, exclusive of the water walls which completely surround the combustion space (with certain exceptions). These five boilers burning pulverized coal not only do the work formerly done by the 48 boilers but have enough reserve capacity to permit shutting down a unit for repairs without interfering with full-load conditions in the refinery. The coal from the bins goes into a Williams swing-hammer crusher, which reduces the size to $^3/_4$ in. From there it is delivered to the unit pulverizers, of which two are installed for each boiler. Part of these pulverizers are motor driven, and part driven by a steam turbine exhausting at 7 lb. pressure. Six of these pulverizers are No. 4 Riley Atritas. For the remaining two boilers four 36-in. Fuller Lehigh unit mills are provided. These are driven by Terry turbines taking steam at 200 lb. pressure and 100 deg. superheat, and exhausting into the low-pressure-steam power line at 100 lb. back pressure. By this arrangement and the provision for an extraction-turbine generator the heat balance at the plant can be definitely controlled. Separate motors drive the feeders and fans serving the Fuller units. Considerable experimenting was necessary before a coal having characteristics suited to the installation was found. The main trouble was with the abrasive quality of some coals, which interfered with pulverization and increased the maintenance costs on the pulverizers.

At present a 1500-kw. Westinghouse turbine generating unit is under order. This is of the extraction type receiving steam at 200 lb. pressure and 100 deg. superheat with a bleeder connection that supplies steam to the process lines at 100 lb. pressure and the exhaust is into another process line at 7 lb. back pressure. When this unit is placed in operation, the operating force will be able to control the heat and power load so as to use all the exhaust steam for heating or process purposes so that no heat waste will occur.

An emergency generating set has been installed. This consists of a Sterling gasoline engine direct connected to a Westinghouse generator of 50 kva. capacity furnishing three-phase current at 440-volts.

As operated at present the plant generates about 8,500,000 lb. of steam in 24 hr. and employs five men per shift in the boiler room. In the old boiler-house plant the operating force consisted of 15 to 18 men per shift. (*Power Plant Engineering*, vol. 32, no. 23, Dec. 1, 1928, pp. 1240–1246, 10 figs., *dp*)

Recent Developments in the Utilization of Bituminous Coal*

Important Points on Preparation, Processing for the Extracting of Liquid Fuels and Other By-Products, Utilization in Power Generation, Etc., Brought Out at the Second International Conference on Bituminous Coal in Pittsburgh

Coal Cleaning

THE matter of cleaning of coal is also referred to in connection with the subject of locomotive fuel. The following deals specially with English conditions. From previous researches it would appear that among the constituents of coal, clarain and vitrain, the "bright" coal constituents, have an ash content not exceeding 1.5 or 2 per cent.[14] Durain, the "dull" coal constituent, has a high ash content which is composed of almost pure clay substance. The ash of durain cannot be removed by ordinary washing or cleaning processes and must be regarded as inherent ash. Fusain, the charcoal-like constituent of bituminous coal, contains both carbon and mineral matter. The latter consists largely of the carbonates of lime and iron, together with a small amount of clayey matter. Because of its friability, fusain is present almost entirely in the form of dust in the coal brought to the surface, except for portions which remain included in unbroken lumps of coal. This dust is mixed up with the dust formed by the more friable portions of the clarain and durain, together with the dust of shale and other minerals. It presents its own big problems in cleaning operation, and is responsible for the formation of slurry in wet washing and of dust in dry cleaning processes.

Recently the difficulties in handling this material have led to the screening out of dust from slag to be washed, but in order to make screening practicable, a fair amount of clean coal above "through-dust" size is allowed to pass the screening, while rather slight percentages of dust remain in the coarse mixture to be submitted to washing.

The separation of coal and free dirt in both the wet and dry cleaning is quite a complicated matter, and depends primarily on at least two factors, specific gravity and size. The result is that present equipment for production of clean coal is comparatively inefficient. The author, R. Lessing, believes, however, that he has developed a process in which the separation depends on specific gravity only. He calls it the "float-and-sink" method. In previously employed processes the importance of de-dusting of the coal was not fully realized. In this case de-dusting coal is used, while a calcium chloride solution of suitable specific gravity is employed as the separating fluid, although other liquids can be used instead. From the commercial point of view, the crux of the process is the removal of the calcium chloride solution from the coal and refuse and its recovery in a form suitable for recirculation. This problem is said to have been solved. The chloride is removed so thoroughly that in most cases the actual chloride content of the clean coal is lower than that of the raw coal.

Coke made from coal cleaned by this process is of particularly high quality. The author considers particularly the employment of such coke in blast furnaces.

In connection with the above-mentioned process, reference may be made to the sand flotation process which is a float-and-sink method designed for separating materials of different specific gravities.[15]

In commercial practice a cylindro-conical container for the fluid mass is generally used, this design providing an effecting method of withdrawing the refuse from the high-density fluid mass. The lower part of such a fluid mass is supported on an upwardly rising column of hydraulic water required for agitation, distribution of the hydraulic water being assisted by a slowly revolving agitator in the fluid mass. The coal is discharged by permitting a portion of the fluid mass to overflow, and portions of the fluid admixed with the coal are removed by screening, such desanding being materially assisted by a comparatively clean body of liquid overlying the fluid mass in the container. The refuse is removed from the base through the rising current of hydraulic water, a water seal being maintained by means of interlocked slide valves.

There are 28 plants in the anthracite regions equipped with this process having an estimated capacity of 12 million tons per year. Sand flotation was also applied to the washing of bituminous coal at the plant of the East Broad Top Railroad and Coal Company at Mount Union, Pennsylvania, but while the mechanical process was apparently successful, the margin of profit in bituminous mining is not always sufficient to justify the plant expenditure.

The need of clean coal from the standpoint of the power and light industries, is particularly emphasized by F. R. Wadleigh.[16]

In the every-day use of the term, by clean coal is meant coal as shipped, from which there has been removed as much as possible of the physical impurities and non-combustible materials. To public utilities, clean coal means greater economy, higher efficiencies, wider range of capacity in plant operation, and higher yields of better coke, gas, and by-products.

The public utilities are also greatly interested in the matter of ash reduction, its fusing or softening temperature, and its clinkering tendencies. Today they are not satisfied with such meager information about the coal they use as they received formerly. They are paying more and more attention to this subject, among other things because of the losses from paying transportation charges and handling costs on material which has no value as fuel.

The economies of coal cleaning were further discussed by Godfrey M. S. Tait.[17] There are two groups of processes, wet and dry. To the former belong the flotation processes such as the Draper washer and the Chance sand-flotation process, as well as the launder system and the table system. Dry washing covers dry-type modifications of the Wilfley table and Peale-Davis system, both of which are used to a considerable extent in America.

No matter, however, what type of plant is contemplated, it is important to know first of all what the possible market for

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* The first half of this review appeared in the January issue.

[14] R. Lessing, Consulting Chemist, London: "The Rational Cleaning of Coal."

[15] T. M. Chance, Consulting Mining Engineer, Philadelphia, Pa.: "The Sand-Flotation Process."

[16] F. R. Wadleigh, Consulting Fuel Engineer, Consolidated Gas Company, New York: "Reasons for the Need of Clean Coal."

[17] Godfrey M. S. Tait, Consulting Engineer, Washington: "The Choice of a Coal-Cleaning Plant."

washed coal is likely to be, as this will determine not only the selection of the process which would produce coal of the particular characteristics desired, but also the advisability of installing the coal-cleaning plant at all.

Coal Cleaning in Germany. This was described by Prof. K. Glinz.[18] From his paper it would appear that while there are a number of wet and dry processes in use, they do not differ very much from those employed in America. In connection with wet processes, special attention is called to the difference between the jigs and the rheowashers, the latter being very efficient in the case of slated coals, and clearly superior to jigs for the treatment of fines and sludge.

The jigging process is still the best suited for cleaning coarse coal.

The commercial situation of coal cleaning in Germany is essentially the same as here, and depends entirely on the price differential between clean and uncleaned coal.

Dry Quenching of Coke

All methods of high-temperature carbonization of coal, except in continuous vertical retorts, involve as a necessary part of operation the discharge of coke from the processing equipment at a temperature of from 1750 deg. fahr. to possibly 2150 deg.[19] An analysis of the conditions prevailing in coke manufacture shows that enormous amounts of energy are here involved. It is not possible at present to use this energy directly in the reduction of the coke-oven fuel. It can be used for producing steam, which involves, however, certain difficulties, and because of this resort has been made to dry quenching. Various schemes have been proposed, but the greatest commercial success was achieved by the process devised by Sulzer Brothers of Winterthur, Switzerland. Fundamentally this consists in passing a stream of inert gases upward through a considerable body of hot coke, the hot gases then passing through or around boiler tubes, then to a fan by means of which they are again returned to the coke. This scheme involves elevating the hot coke if the plant is placed above yard grade, or elevating the cold coke if the plant is below ground level. It has the important advantage of counterflow of coke and circulating gases. The operating conditions including the important consideration of coke dust are discussed in the original article.

Careful comparisons have been made at Rochester, N. Y., between dry- and wet-quenched coke for use in water-gas machines. Several tests have shown that about 5 per cent better fuel economy is obtained when dry-quenched fuel is used. It is difficult to give a satisfactory theoretical explanation of this, since it is quite impossible to account for the better performance on the basis of the heat required to drive off the higher moisture content of the wet-quenched fuel. The statement has been made that the absence of moisture permits an extension of the reducing zone in the water-gas machine and consequent fuel economy. It may be that this explanation is correct, but sufficient experimental evidence is not yet available to enable a conclusion. It is possible that the better screening, the more uniform size, and the physically stronger coke permit a more uniform and regular operation of the water-gas machine, and that this accounts for the better results obtained. Whatever the explanation may be, the experimental evidence seems entirely convincing that in the production of carbureted water gas about 5 per cent better fuel economy is obtained using dry-quenched coke.

Detailed consideration of costs involved is given in the original article. From these it would appear that steam can be made at a cost of 11.58 cents per 1000 lb., this figure including 16 per cent fixed charges. The heat balance of the Rochester, N. Y., plant shows an average steam production of 1005 lb. per ton of coke cooled.

Boiler-Plant Problems

Practically every power-plant engineer having to design a new plant is faced with the problem of making a selection between the stoker and pulverized-coal firing. According to James W. Armour,[20] the two, when properly installed, give about the same result at about the same cost. The first cost is said to be about $65 per hp. for the stoker as against $70 for pulverized coal. The difference is, however, mainly in the furnace cost, so that if solid walls had been used in the pulverized-coal-fired boiler the first cost of the two would have been more nearly equal. The operation costs are equal, while the maintenance costs are expected to be approximately the same. The maintenance of the air-cooled walls of the pulverized-coal-fired furnace will be considerably less than with the solid coal of the stoker-fired furnace. On the whole, however, in the matter of maintenance there seems little to choose between stokers and pulverized coal, and the efficiencies are very much alike when both types are properly considered. It is only where load conditions are such that there are long banking periods that the stand-by loss with pulverized coal is less than with stokers. The flexibility of operation is said to be the same. As regards fuel, stokers permit greater latitude in selection of coal than does hand firing, and pulverized-coal firing permits greater latitude than stokers. Coals which give the best results with stokers usually also give the best results with pulverized coal, while poor coal is poor in both cases. The author's conclusion is, therefore, that the art of burning bituminous coal has reached that point where it is difficult to choose between pulverizers and stokers. The main recent improvements in the latter have been the use of preheated air, proper application or admission of air to the fuel bed, and substitution or supplementing of refractory-lined furnaces with water-cooled or air-cooled walls. These improvements are applicable not only to large boiler units but also to small industrial plants, except water-cooled walls, and even these have certain useful applications.

Among the features of boiler operation discussed at the conference was the question of removal of ash and loss of carbon from boiler furnaces.[21] The following conclusions are cited from the original paper.

1 The removal of ash from mechanical stokers has been greatly improved, and the percentage of carbon lost to the ashpit has been materially reduced.

2 The removal of ash from pulverized-coal-fired furnaces has been greatly facilitated by water-cooled hoppers.

3 The latest method of removing ash is in the form of molten slag.

4 Carbon loss in flue dust from both stokers and pulverized-coal-fired boilers is an important problem which deserves much more study than it has received.

5 Carbon loss in flue dust from pulverized-coal-fired furnaces increases with

a Anthracite or coal with high fixed carbon
b Coarser pulverization

[18] Dr. K. Glinz, Professor, Technische Hochschule, Berlin: "Coal-Cleaning Problems of Today."

[19] D. W. Wilson, Vice-President, Dry Quenching Equipment Corporation, New York: "The Dry Quenching of Coke."

[20] James W. Armour, Engineering Manager, Riley Stoker Company, Worcester, Mass.: "The Modern Stoker and Its Comparison with Pulverized-Coal Firing."

[21] D. S. Jacobus and E. G. Bailey, respectively Advisory Engineer, Babcock & Wilcox Co., New York, and President, Fuller Lehigh Co., Fullerton, Pa.: "Removal of Ash and Loss of Carbon from Boiler Furnaces."

c Cold furnaces
d Delayed mixture with air
e Low excess air, and
f High rates of combustion.

6 Slagging of boiler tubes is accentuated by the lower fusing temperature of ash, large size of ash particles, and by high temperature and velocity of gases entering the boiler tubes.

Boiler Furnaces for Bituminous Coal. A general survey of this subject was given by A. G. Christie.[22] One of the most significant factors in recent stoker and pulverized-coal developments is the great efficiency at high ratings. Tests have been reported on the boilers and economizers at the Huntley Station, Buffalo, where the combined efficiency did not fall below 85 per cent at any rating up to 500 per cent. Advances are being made in every direction. It is only within the last few years that the important influence of radiant heat as a means of heat transfer from burning fuel to boiler furnaces has been appraised. In the matter of furnace walls profound changes have taken place, the solid wall having been replaced in some places by the hollow refractory wall, and in other places by the water-cooled metal wall. Increased knowledge of chemical phenomena suggests the idea that some refractories may have catalytic effects on the combustion of coal, while furnace gases may have an action on the refractory walls and produce slagging. Water-cooled furnace walls cost more than simple refractory walls, and a large number of economic and technical factors have to be taken into consideration before a decision can be made on what type of wall should be adopted. One of the most significant developments in recent furnace construction has been the increasing use of air preheated by heat recovered from the escaping flue gases. While the general idea is now new, it is only within recent years that the advantages resulting from its proper application to stationary boilers have become fully recognized. The increased furnace temperature resulting from the use of preheated air is effective in raising boiler efficiency, provided the boiler-furnace surfaces are properly disposed to take advantage of this gain. High degrees of air preheat are now sought, and temperatures of 300 to 500 deg. fahr. are being tried on stokers. With powdered coal the degree of preheat is limited only by the ability of the preheater to withstand the gas and air temperatures, and it is said that air preheated to 800 deg. fahr. has been used abroad.

Only certain parts of this interesting and extensive paper can be referred to here. As regards powdered-coal furnaces, the importance of continued turbulence in the furnace itself as a means of accelerating the combustion of pulverized coal is now becoming generally recognized. Turbulence is necessary to sweep away the products of combustion that surround a coal particle after ignition has started, and to provide this particle with fresh supplies of oxygen to continue combustion. The more rapidly this supply of oxygen is furnished, the faster the combustion, the higher the flame temperature, and the better the furnace efficiency. Turbulence must not only be set up in the entering mixture, but should be maintained in the furnace itself during the entire combustion process. Horizontal turbulent burners should develop such high rates of combustion that the flame will not extend more than 15 ft. from the burner outlet. It is significant that the vertical long-flame burner is being discarded in England in favor of the horizontal turbulent burner.

Others have called attention to the danger of too short flames. The carbon particles which remain after the volatile gases are driven off, burn more slowly than the gases. These unburned particles may be projected beyond the short flame and be cooled by radiation before combustion is complete, which would result in a higher loss of unburned carbon in the flue gases. This, however, in no way lessens the importance of violent turbulence in the furnace.

Turbulent burners are a recent development, and many improvements can be made on them to lessen the possibilities of burning out the metal parts, to improve operation at low ratings, to speed up ignition after leaving the burner, and to insure more rapid combustion in the furnace.

Most of the turbulent burners are of the horizontal type. This form is generally used with unit mills. Several forms of tangential firing produce great turbulence by their cyclone effect, and have developed high rates of combustion. This method of firing will also be used more extensively.

Bituminous coals low in volatile matter take a longer time to burn than those high in volatile constituents. Hence the carbon loss up the stack will be greater with the low-volatile coals when the same furnace volume and flame length are used. Coarse grinding also leads to slower combustion and higher carbon losses up the stack. Greater attention should be directed to these carbon losses and to means whereby they may be diminished.

The preceding paragraphs have indicated certain trends in the development of boiler furnaces for burning bituminous coal both on stokers and as powdered coal. In general, furnaces will be built to secure maximum excess air quantities, and hence high CO_2. As a consequence the highest possible furnace temperatures will be developed, and this will lead to increased heat transfer and improved efficiency. All furnace walls will be water-cooled to permit these desired operating conditions at high ratings, and this construction may be expected to become standard practice.

Ash difficulties may be lessened by better raw-coal preparation at the mines so that less ash is received at the plant.

The development in powdered-coal equipment has forced stoker manufacturers to make such improvements in stoker and furnace construction that the competition between the two forms of firing is now intense. As a consequence of this, one may expect further improvements in both methods which will lead to better efficiency and to refinement of equipment. Turbulence permits complete combustion and maximum furnace temperature with minimum excess air for powdered coal. Overfront air admission and arches tend to mix furnace gases on stokers. Future development will provide still greater turbulence in stoker furnaces as well as in those for pulverized coal.

The end of improvement in equipment for burning bituminous coal is not yet in sight, and one may look forward to the development in the near future of still better, simpler, and cheaper furnaces.

Clinkering in Boiler Furnaces. Purchasing agents and plant superintendents[23] have been looking forward to the time when laboratory tests would be devised, which would indicate with a reasonable degree of accuracy, the behavior of a given coal in a boiler furnace of a given type under given operating conditions. It is very doubtful if such laboratory tests could be devised, because there are so many factors entering into the problem. It is believed, however, that if the problem is given the scientific study its importance warrants, laboratory tests will be developed which will yield much more information than is now available.

A cooperative research between the United States Bureau of Mines, the Carnegie Institute of Technology, and two large power companies was carried on for two years on the subject of the fusibility of coal ash and its relation to clinkering. This repre-

[22] A. G. Christie, Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md.: "Boiler Furnaces for Bituminous Coals."

[23] Thomas J. Estep, Professor of Mechanical Engineering, Carnegie Institute of Technology: "Clinkering of Coal Ash in Boiler Furnaces."

sents about all the information available on this subject. Probably the weakest point in this investigation is that the clinkering tests were made in an experimental furnace that had practically nothing in common with a boiler furnace, and the results obtained are purely relative. In defense of this experimental furnace, it may be said that in an investigation of this kind, certain conditions must be kept under complete control while others are varied, and this cannot be done very well in large-scale tests without a great deal of trouble and expense.

In the preparation of this paper some further study was made of the data reported in certain papers referred to by the author with the following results:

There is no relation between the silica in the ash and the ash fusion temperature.

There is no relation between the percentage of coal sinking in a solution of 1.35 specific gravity and the fusion temperature of the ash.

There is no relation between the percentage of coal floating on a solution of 1.35 specific gravity and the fusion temperature of the ash.

There is no relation between the amount of lime (CaO) in the ash and the ash fusion temperature.

(Note: In the following, the word "clinker" refers to that portion of the refuse passing over a 2-in. screen, and "float-and-sink portions" those parts floating and sinking in a solution of 1.35 specific gravity).

There is no relation between the clinker expressed as a per cent by weight of the original coal and the ash fusion temperature of the float portion.

When the clinker in per cent by weight of the original fuel is plotted against the ash fusion temperature of the sink portion smoother curves result than those shown in original papers.

When the clinker as per cent by weight of the original fuel is plotted against the ash fusion temperature of the original fuel, smoother curves result than those shown in original paper. There is no relation between the clinker as a per cent by weight of the ash in the sink portion to the fusion temperature of the ash in the sink portion.

There is no relation between the clinker as a per cent by weight of the ash in the sink to the per cent by weight of the ferric oxide in the sink ash.

There is no relation between the clinker as a per cent by weight of the original coal to the per cent by weight of the pyritic sulphur in original coal.

A Coke-Burning Domestic Boiler. Complete utilization of new fuels is possible only when proper equipment becomes available. In Europe coke has been used for a long time as domestic fuel. In the United States it is a comparatively new material in so far as this field is concerned, and new equipment is needed. One of the main reasons for this is to be found in the fact that coke needs a very large fuel magazine, almost twice as large as that required for anthracite.[24] The new domestic boiler developed in America on the basis of European practice, and described before the conference by Dr. Charles W. Brabbée, is therefore of interest.

Fuel Tests and Plant Operation. The testing of solid fuels serves several purposes. It adds to scientific knowledge of the fuel substance; and it procures data which are required to control and operate plants in which the calorific power stored in the fuel is converted into another form. This paper[25] deals only with those tests and observations which serve this latter purpose.

The operating requirements of a plant demand, first of all, quick determinations, not only because "time is money," but also because the results of the tests can have their full effect on the control of plant operation only when they are at the disposal of the supervisor at the proper time. With this end in view the author in the first place made an effort to reduce the time required for one of the most important fuel tests, i.e., the determination of moisture. The old method hitherto almost universally used for the determination of moisture in solid fuels, by weighing before and after drying, takes about two hours. Treating fuel with xylene and determining the moisture by subsequent distillation takes an average of 45 minutes. The author has been successful in working out a method, the results of which are equally reliable, and which will not take more than 8 minutes' time.

Considerable difficulties were encountered in the endeavors to split up the coal substance by new methods. The usual way of utilizing bituminous coal may be considered as a process of heat conversion. The basis and the range of this process are primarily defined by the amount of heat stored in the fuel, i.e., by its calorific power or value. The calorific power, however, indicates only the total amount of the usable heat but does not permit any deductions as to the *kind* of conversion of the fuel. It is well known that this kind of conversion is in a high degree dependent upon the distribution of the energy of the coal between volatile and non-volatile substances. The relative proportion of both these substances forming the fuel plays a very important part not only in burning the raw fuel but even more so in generating heat from pulverized coal. In fact, it plays a most important role in every kind of fuel utilization.

The usual short or proximate analysis of coal offers an easy way to split up the coal substance into moisture, fixed carbon, ash, and volatile matter, the latter being determined by difference of weight. The results of this test give only an approximate insight into the nature of the fuel; or rather, they *appear* to give only such an insight because the results of these tests have a very doubtful value for the deduction of reliable calculations and therefore can be applied only within very narrow limits.

A process is being used which in its extent is predetermined by a certain amount of heat that can be measured in calories; and the proximate analysis is characterized by giving the results in per cent by weight for the different parts of the determination, so that we talk about "per cent by weight of volatile substances" or gases, while only their calorific value or power really serves as a reliable comparison. This leads at once to the conclusion that the short or proximate analysis does not form a suitable basis for the proper characterization of fuels.

In this connection the author has tried to follow a new path by dividing the heat stored in the fuel into the three single phases, "solid, liquid, and gaseous," corresponding to the products of the destructive distillation of coal: coke, tar, and gas. These products are always yielded whenever coal is being heated, irrespective of whether it is consumed by burning it in a fire or by converting it by other means. This *division* of the heat contained in the fuel into the three single phases, "solid, liquid, and gaseous," offers a way to determine, irrespectively of the kind of fuel, a clear and reliable basis for predicting the possibilities of the conversion of fuel of every kind by combustion, distillation, or total gasification.

In reality the above new method amounts only to combining a number of fuel tests which are already in use. However, these methods have been standardized in such a way that *all results obtained in the determination of the fuel are expressed in common values representing the converted heat.*

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[24] Dr. Charles W. Brabbée, Director, Institute of Thermal Research, American Radiator Co., Yonkers, New York: "Coke-Burning Domestic Boiler."

[25] Dr. M. Dolch, Director of the Institute of Technical Chemistry of the University at Halle (Saale), Germany: "Fuel Tests and Plant Operation."

MISCELLANEOUS

Locomotive Fuel. The coal conference made a contribution to our general knowledge of fuel utilization by causing various engineers connected with the burning of fuel to analyze this problem in a manner never so completely done before. As an instance of this may be cited the analysis of reasons for the use of coal as locomotive fuel given by W. L. Robinson.[26] The problem of coal fuel is a very important one for American railroads, because out of the average annual production of more than half a billion net tons, about 126 million is consumed as locomotive fuel. Furthermore, more than 50 per cent of the revenue tonnage of the railroads consists of products of mines, the bulk of which is bituminous coal and coke, and it has been estimated that the railroads have more money invested in facilities for transporting coal and coke than is invested by the coal producers themselves in operating coal mines and their equipment. Fuel is by far the most expensive single material purchased by the railroads, and fuel expense stands second only to wage expense in railroad operation.

The choice of railroad coal is affected by other considerations than the simple ability to get locomotives from beginning to end of the runs.

Under present average conditions it requires about half a ton of coal to start a freight train and bring it up to a running speed after a stop. It is therefore of great importance to eliminate all fuel troubles that may lead to delays or stops, and one of the most promising modifications of conventional practice observable at present is the extension of the length of run of locomotives.

The combustion in the locomotive firebox takes place in such a manner that more than 75 per cent of the heat of the coal is rejected to the stack. In recently designed locomotives, an effort to reduce the loss is made by more efficient transfer of heat to the steam and recovery of heat from the exhaust steam to heat the boiler feedwater.

Because it has been impossible to build a perfectly level track on railroads, there is a continuous change in the power output of the locomotive and in the demand of the engines for steam. The desirability of realizing the maximum hauling capacity of the locomotive on the ascending grade makes it advisable to use a quick-burning fuel which immediately upon introduction gives off its gases high in heat content, thus permitting the forcing of the fire at the critical points of the run. The practical value of maximum steam capacity overbalances the reduction of fuel efficiency resulting from the high rate of combustion of high-volatile fuel in a firebox of restricted volume.

As regards the size of locomotive coal, careful road tests with stoker-fired locomotives have shown that on the basis of equivalent operation there is an increase of 20 per cent in consumption of 2-in. screenings as compared with run-of-mine, and an increase of 25 per cent in consumption of $^3/_4$-in. screenings as compared with 2-in. screenings.

The moisture and ash contents of locomotive coal are important, particularly the latter, because of its possible effect upon the rate and efficiency of combustion. Ash with clinkers in a locomotive firebox is particularly objectionable, and the results obtained from early attempts to use pulverized coal obtained from miscellaneous sources in the conventional locomotive firebox were discouraging largely because of excessive slagging of the flues. The crushing of coal in the present stokers on locomotives by increasing to some extent the proportion of very fine sizes, also increasing the cinder stack loss, which has become a serious problem in heavy through passenger service on some roads. Improvement of this condition is anticipated.

One of the most important methods of saving coal is the elaborate supervision for locomotive fuel economy developed on American railroads. The gradually increasing proportion of locomotives of greater capacity and better design has also contributed to the improvement in economical utilization of locomotive fuel during the past fifteen or twenty years. Of equal, if not greater, promise is the prospect that more competitive conditions in the bituminous-coal business will cause installation of equipment that will permit shipping cleaner coal. Today only a comparatively few mines are so equipped. The large producers are, however, experimenting with more elaborate systems of economically loading, conveying, cleaning on the flotation principle and marketing of separate sizes adapted to particular uses. In the northern parts of coal-producing territories the present tendency appears to be in favor of the principle of air flotation in the coal-cleaning equipment.

Coal Specifications. In this field the work in America and that in Denmark have taken different paths. In Denmark[27] The Danish Gas Works Association, members of which are mainly municipal gas plants, have established an organization assisting in coal purchasing. The method of procedure is briefly this. The gas works takes samples from all shipments of coal, and tests the samples in accordance with standardized methods specifically worked out for this purpose. Then the analysis together with essential information as to the shipment, such as name and location of the mine, general condition of the coal as to size and dryness, etc., is forwarded to the association, which prints all this data on special blanks. These blanks are then distributed to all the active members of the association, who may be governed thereby in future purchase of coal. Only certain tests are made by the plant under this arrangement, the effort being to extend the field of testing. Thus the Association in the future intends to have included in the standard tests the determination of the fusion point of ash in oxidizing atmosphere.

In America the work is apparently taking a somewhat different direction.[28] At the time of the First International Conference of Bituminous Coal, a meeting of representatives of various professional societies and of industrial, educational, and governmental organizations was held in Pittsburgh to consider what action, if any, should be taken on the classification of individual American coals. This meeting was called by the American Engineering Standards Association and resulted in the formation of a committee sponsored by the American Society for Testing Materials. This committee later broke into three, namely, on scientific classification, on use classification, and on marketing practice. The very extensive and interesting reports of these committees cannot be presented here due to lack of space. The conclusion arrived at, in reference to scientific classification, is that from a chemical point of view ultimate analysis appears superior to proximate analysis as a basis for classification, and that apparently a definite relation exists between the ultimate analysis of a coal and its calorific value. The sub-committee is now engaged in correlating the various classification systems and in developing graphic methods for operating them.

The committee on use classification has so far appointed subcommittees to obtain data as to the major uses of bituminous coal, and is working out specifications and lists of desirable characteristics for these coals. It is intended to make the use classification secondary to scientific classification and to have it correlated with the latter as far as possible, while scientific classification is made to depend on two primary factors: the first being the composition and type of the original coal-forming vegetation, and the second, the degree of coalification of the vegetable residue.

[26] W. L. Robinson, Baltimore and Ohio Railroad, Baltimore, Md. "Locomotive Fuel."

[27] P. E. Raaschou, Professor, Royal Polytechnical College, Copenhagen: "Cooperative Control of Coal Purchases by Gas Works."

[28] A. C. Fieldner, Chief Chemist, U. S. Bureau of Mines: "Classification of North American Coals."

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

The Specific Heat of Superheated Steam at Pressures of From 30 to 120 Atmospheres and From Saturation Temperature to 450 Deg. Cent.

KNOBLAUCH, Jakob, Hilde Mollier, Winkhaus, and Raisch have at various times published results of series of investigations covering the specific heat of steam up to 30 atmos. pressure. Substantially the same method of measurement was used in all of these investigations. Steam generated in a boiler by combustion of coal or oil or produced electrically was heated by gas or an electric current to the desired temperature and then further heated in a calorimeter to a given temperature by a precisely measured input of electric energy. This steam was then passed through a condenser and weighed. From the amount of steam passing through per hour, from the heat supplied to the calorimeter, and from the resulting rise of temperature the specific heat c_p at constant pressure may be calculated on the assumption that the heat is completely transferred to the steam and not partly lost to the ambient medium.

However, a heat loss was actually experienced in previous investigations which was determined in the following manner. After the test proper had been completed a supplementary test was made, and in this test, after the steam supply had been cut off, the amount of heat necessary to maintain the calorimeter at the same temperature which it had during the main test, was determined. This method of procedure constituted a weak spot in the previous c_p determinations, but it could not be helped and therefore had to be managed one way or another. Recent progress in the technique of temperature measurements has, however, made it possible to provide such protection that heat losses from the calorimeter have been completely eliminated. This was achieved by an extensive development of the idea of keeping the ambient medium of each part of the calorimeter at the same temperature as the calorimeter itself, this being done by means of electrical balance heating. Actually in the case of the calorimeter used in the tests here described this required no fewer than eight such complementary heating devices.

In connection with the recent extension of tests to the region of from 30 to 120 atmos., several tests were carried out on steam at lower temperatures in order to obtain figures that would permit a comparison with previously obtained experimental results. This was of particular interest because previous investigations had extended over a period of some twenty years, and while they had been carried on in the same laboratory, various observers had been employed in the work, and there had been changes in the apparatus used. It is gratifying to note that the improvement in the art of measurement has indicated slight deviations from previous results only in certain ranges, namely, in the neighborhood of saturation or in the range of great superheats, i.e., in places where extrapolation was always considered to be somewhat uncertain. It may be stated in advance that the tests here described have shown that the same laws hold in the range of the very high pressures, namely, that c_p increases for any given temperature with the pressure, and at a given pressure the approach to saturation indicates a rapid increase in value with the pressure.

The authors present in some detail the theoretical foundations for their method of calculating the specific heat. The only part of special interest is a correction for the value of c_p which they make. The original formula which they derive is completely valid only for the case where the pressure of the steam does not vary during its flow through the calorimeter. As a matter of fact the steam pressure at the exit from the calorimeter for a temperature t_2 must be somewhat lower than when it enters the calorimeter at the temperature t_1, as obviously there would be no flow of steam if there were no difference in pressure. A correction for the temperature variation therefore becomes necessary, and the value of this correction Δt has been computed from the as yet unpublished throttling tests made by Dr. H. N. Davis of Stevens Institute of Technology. The final formula is therefore

$$c_p = \frac{Q}{G\,[(t_2 - t_1) + \Delta t]}$$

where Q is the quantity of heat expressed in kilogram-calories and determined from the voltage and amperage of the electrical heating current; and G is the weight of steam flowing through the calorimeter per hour in kilograms.

The detailed description of the experimental installation in the original article cannot be given here because of lack of space, except that portion dealing with the electrical balance heaters referred to above. This electrical heating arrangement consists of eight parts, I to VIII (Fig. 1). The reason for using so many parts is to maintain the desired temperature at each place on the outside of the calorimeter. The heating units of the protective jackets I to VI consists of chrome-nickel strips electrically insulated by micanite and built into sheet steel, the latter being nickel plated in order to reduce heat radiation. Preliminary tests showed that the supporting flanges of the calorimeter made their heat-conducting influence felt as far as the admission and exit steam piping, and even to the parts lying within the protective jackets. To avoid this, special heating units VII and VIII were provided. The temperatures of the heating units and of the various calorimeter surfaces are determined by thermocouples located at positions 1 to 15 in Fig. 1. The purpose of all these devices is to prevent an exchange of heat between the inside of the calorimeter and the ambient medium. It is further necessary to see that exchange of heat between the temperature-measurement stations t_1 and t_2 and the calorimeter is prevented as much as possible. Such an exchange could occur due to the fact that in the inlet pipe the lowest temperature t_1 prevails, in the calorimeter the highest temperature, and in the inlet pipe a temperature t_2 somewhat lower than that in the calorimeter. To prevent an exchange of heat between these places, three alu-

TABLE 1 VALUES OBTAINED IN TESTS

(*Dauer des Beharrungszustandes;* Duration of state of equilibrium; *Art der Messung;* Method of measurement; *Th*, Thermocouple; *W*, Resistance.)

Versuch Nr.	Tag	p at	$\frac{t_1+t_2}{2}$ °C	t_2-t_1 °C	Δt °C	G kg/h	Q kcal/h	Dauer des Beharrungszustandes min	c_p kcal/kg °C	Art der Messung
1	5. 10. 27	19,8	332,9	5,94	0,018	6,308	20,45	160	0,544	Th
2	6. 6. 28	19,9	334,8	11,81	0,088	15,751	101,1	120	0,540	W
3	4. 10. 27	19,9	335,9	12,01	0,065	13,328	86,2	120	0,536	Th
4	12. 6. 28	29,9	241,6	3,62	0,064	15,414	45,43	140	0,801	W
5	10. 10. 27	29,9	246,6	10,94	0,066	13,580	115,1	120	0,769	Th
6	12. 6. 28	29,9	259,3	10,44	0,056	15,309	114,0	70	0,709	W
7	11. 10. 27	29,8	283,8	10,48	0,062	15,196	102,1	50	0,638	Th
8	11. 10. 27	29,8	320,1	10,73	0,048	13,931	87,9	80	0,585	Th
9	21. 6. 28	29,9	353,9	5,08	0,031	13,457	39,07	90	0,568	W
10	21. 6. 28	29,9	358,4	14,23	0,029	13,311	108,1	70	0,569	W
11	12. 10. 27	29,8	386,3	11,18	0,054	13,826	85,9	75	0,553	Th
12	25. 6. 28	29,9	433,9	6,21	0,036	14,840	51,6	80	0,556	W
13	25. 6. 28	29,9	437,0	12,40	0,035	14,814	102,9	70	0,559	W
14	1. 8. 28	29,9	493,2	6,56	0,025	13,723	50,65	70	0,560	W
15	31. 7. 28	40,1	252,8	3,03	0,043	14,093	40,10	80	0,927	W
16	18. 6. 28	40,1	257,3	2,79	0,056	15,779	40,87	100	0,909	W
17	4. 11. 27	40,1	263,8	7,46	0,042	14,594	91,4	70	0,835	Th
18	5. 11. 27	40,1	274,0	9,32	0,027	12,395	90,3	100	0,779	Th
19	5. 12. 27	40,1	288,5	9,16	0,046	14,400	94,6	120	0,714	Th
20	5. 12. 27	40,1	322,7	9,87	0,044	14,983	94,1	90	0,633	Th
21	26. 6. 28	40,1	371,2	10,42	0,038	14,313	90,4	60	0,595	W
22	26. 6. 28	40,1	403,7	11,28	0,032	14,480	94,2	80	0,576	W
23	26. 6. 28	40,1	436,5	11,34	0,031	14,936	97,1	100	0,571	W
24	20. 6. 28	40,1	436,8	10,96	0,032	15,950	100,0	120	0,571	W
25	2. 8. 28	40,1	494,0	8,18	0,019	13,729	64,1	60	0,569	W
26	15. 6. 28	60,2	280,3	2,16	0,028	15,200	36,75	90	1,105	W
27	15. 6. 28	60,2	283,8	7,46	0,026	14,724	114,7	60	1,040	W
28	28. 11. 27	60,1	287,5	7,08	0,016	12,220	86,3	80	0,994	Th
29	2. 11. 27	60,2	301,1	8,92	0,015	12,078	94,9	60	0,879	Th
30	28. 11. 27	60,1	324,6	9,83	0,022	14,473	107,4	180	0,754	Th
31	22. 11. 27	60,1	334,6	9,37	0,023	15,097	103,3	80	0,729	Th
32	27. 6. 28	60,2	368,0	11,15	0,019	13,685	100,2	90	0,655	W
33	22. 11. 27	60,1	369,2	10,15	0,015	13,375	87,2	25	0,641	Th
34	13. 6. 28	60,2	429,0	10,13	0,016	16,280	100,0	80	0,605	W
35	27. 6. 28	60,2	437,7	13,71	0,016	13,103	108,9	90	0,606	W
36	11. 7. 28	80,0	297,6	3,12	0,018	14,477	61,6	80	1,355	W
37	11. 7. 28	80,0	300,5	7,65	0,014	13,879	134,8	80	1,267	W
38	25. 10. 27	79,9	309,7	8,27	0,028	17,723	165,2	45	1,123	Th
39	22. 10. 27	79,9	326,2	12,99	0,009	10,533	126,8	40	0,927	Th
40	10. 11. 27	79,9	341,5	9,47	0,017	14,924	117,2	100	0,828	Th
41	3. 7. 28	80,0	375,0	5,47	0,011	13,046	51,5	80	0,721	W
42	3. 7. 28	80,0	377,5	10,60	0,011	12,996	99,9	160	0,724	W
43	5. 7. 28	80,0	421,0	5,95	0,013	14,278	55,6	70	0,653	W
44	5. 7. 28	80,0	423,7	11,28	0,014	14,689	108,9	130	0,657	W
45	17. 7. 28	100,2	314,9	5,18	0,009	12,675	100,4	70	1,527	W
46	29. 11. 27	100,2	317,9	3,47	0,006	13,011	68,8	65	1,526	Th
47	17. 7. 28	100,2	318,0	9,79	0,009	12,636	176,1	80	1,422	W
48	29. 11. 27	100,2	324,5	9,61	0,005	12,543	163,2	60	1,354	Th
49	1. 12. 27	100,2	335,0	10,26	0,010	13,370	154,8	90	1,128	Th
50	6. 12. 27	100,2	352,5	10,80	0,012	12,270	125,2	60	0,944	Th
51	6. 12. 27	100,2	376,1	10,79	0,010	12,563	111,2	120	0,819	Th
52	19. 7. 28	100,2	411,9	9,85	0,011	14,379	102,7	70	0,724	W
53	19. 7. 28	100,2	410,1	4,76	0,010	14,112	49,30	70	0,732	W
54	24. 7. 28	120,1	326,9	3,75	0,008	13,638	100,9	90	1,967	W
55	24. 7. 28	120,1	328,6	4,62	0,008	13,393	115,9	60	1,870	W
56	27. 7. 28	120,1	335,4	7,93	0,008	12,574	154,7	70	1,550	W
57	11. 11. 27	120,1	342,2	10,81	0,005	11,301	166,7	70	1,363	Th
58	15. 11. 27	120,0	345,1	9,58	0,007	13,190	167,5	50	1,324	Th
59	11. 11. 27	120,1	352,7	11,02	0,004	10,289	136,1	80	1,200	Th
60	15. 11. 27	120,1	365,9	10,17	0,002	10,468	109,3	80	1,026	Th
61	27. 11. 27	120,1	389,0	9,75	0,006	11,271	94,8	120	0,862	Th
62	27. 7. 28	120,1	427,6	9,52	0,006	13,744	97,5	70	0,743	W

minum sheets were inserted vertically and three horizontally. The authors describe the method of measuring the temperature in detail as well as the control measurements.

The methods of testing described in the original article were quite complicated as each factor that might have affected the results had to be accounted for. To determine the various factors of the apparatus used, 25 preliminary tests were needed, and these were followed by 68 main tests. Of these latter six have been set aside as possibly being vitiated by certain disturbing occurrences. The quantity of steam used was from 12 to 15 kg. per hr., and the pressures 30, 40, 60, 80, 100, and 120 atmos. The upper temperature limits were about 500 deg. at 30 and 40 atmos. pressure, and averaged 425 deg. cent. at the higher pressures. The rise of temperature in the calorimeter varied between 2 and 14 deg. cent. When working closely to the saturation temperature the approximation of the tempera-

ture at the inlet to the calorimeter to the saturation temperature was made not less than 2 deg. cent. in order to prevent the entrance of the condensate into the calorimeter. In these tests the superheat $(t_2 - t_1)$ was kept as low as possible in order to bring as near to the saturation temperature as possible the temperature $(t_1 + t_2)/2$ of c_p.

Both at high pressures and at high temperatures control tests were deliberately carried out with high and low superheat in the calorimeter, the purpose of these being to determine whether in fact the heat exchange with the ambient medium was reduced to

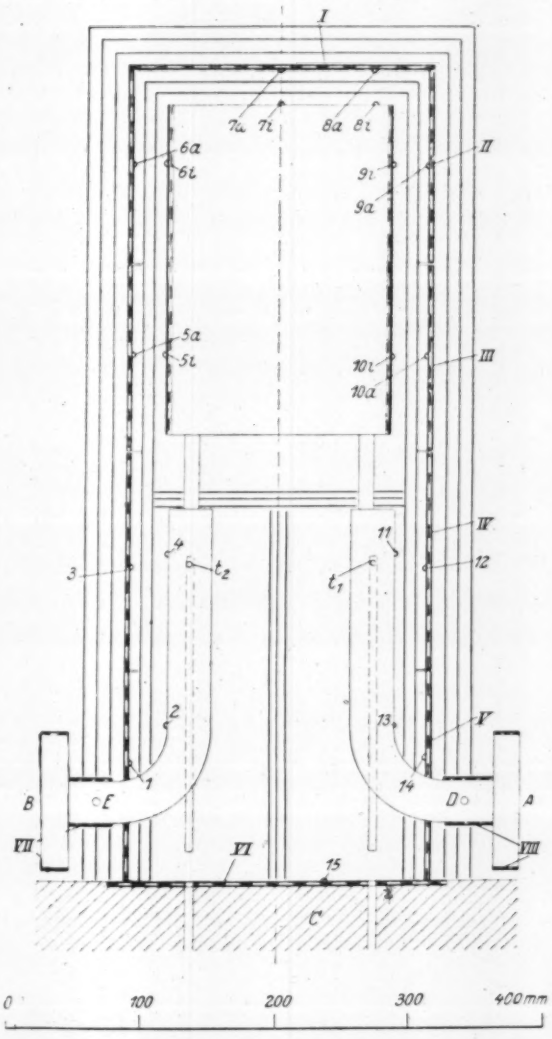


FIG. 1 CALORIMETER USED IN TESTS

(*A*, steam inlet; *B*, steam outlet; *C*, bottom; *D*, pressure-measurement station; *E*, pressure-measurement station; *I* to *VIII*, electrical balance heating; *1* to *15*, thermocouples; t_1 and t_2, temperature-measurement stations.)

zero as aimed at by the test method. Had this not been the case it would have been shown more clearly at low superheats than at high superheats and would have given variable values for c_p. Actually the c_p values agreed in both cases.

The values obtained from the 62 tests which are considered reliable are given in Table 1 and are plotted in Fig. 2. The values observed by means of thermocouples are indicated by small circles, while those obtained by resistance thermometers are shown by crosses. No substantial variation between the two sets of results is observable.

By connecting the values belonging to the same pressures the authors obtained the c_p isobars in the specific-heat–temperature diagram.

It has been found in accordance with previous determinations

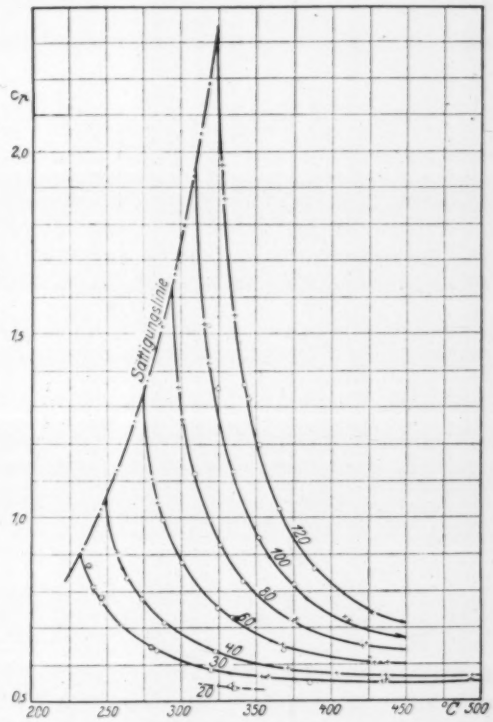


FIG. 2 SPECIFIC-HEAT ISOBARS IN THE SPECIFIC-HEAT–TEMPERATURE DIAGRAM

(*Sättingungslinie* = saturation line.)

made at pressures up to 30 atmos. that c_p for a given temperature increases with the pressure and at a given pressure falls off with increase of temperature from the saturation point. This decrease increases with increase of pressure.

In former tests made with lower pressures it was found that after a decrease in the neighborhood of saturation there was an increase of c_p in the range of high superheats with further increase of pressure. This remarkable behavior of the specific heat has a tendency to shift toward higher and higher temperatures with increase of pressure. It appears clearly at pressures of 30 atmos., as indicated at 40 atmos. by the fact that c_p maintains a constant value at temperatures between 440 and 500 deg. cent., but can no longer be observed at still higher pressures within the temperature range used in the present series of tests.

In order to connect quantitatively the new observations at pressures above 30 atmos. with the older ones at pressures up to and below 30 atmos., the values taken from the Knoblauch and Raisch measurements have been plotted on Fig. 2 as double circles. In addition to this the portion of the former isobars lying at 20 atmos. pressure has been plotted in a broken line from data obtained by three new tests made at about 335 deg. cent. The accord with the values obtained earlier is very good. A detailed discussion of the very small variations as well as their elimination is left for inclusion in the new edition of "Tables and Diagrams for Steam," by Knoblauch, Raisch, and Hausen, which work first appeared in 1923. While the older tables and diagrams have been made on the basis of observation of specific-heat values up to 30 atmos. and extrapolation up to 60 atmos., the new edition, which is already under way, will extend

the pressure range to 120 atmos., and it will be possible by extrapolation to extend it still higher. In order to lay an experimental foundation for this extrapolation, it is proposed to make a series of measurements up to 250 atmos. in an experimental installation which has been already designed. In this connection conditions will be investigated at the critical pressure of 225 atmos., where the specific heat should be equal to infinity. (Oscar Knoblauch and W. Koch in a communication from the Laboratory of Technical Physics at the Munich Institute of Technology; abstracted through *Zeitschrift des Vereines deutscher Ingenieure*, vol. 72, no. 48, Dec. 1, 1928, pp. 1733-1739, 16 figs., *eA*)

Burning Brown Coal Under Boilers in Australia

THE State of Victoria possesses enormous resources of low-grade fuel in the form of brown coal. It was therefore natural for the State Electricity Commission to try to use it. One plant did use a coal from the Morwell Mine containing about 50 per cent moisture and of a hard nature. However, the supplies of even this coal are limited, while another type of coal was available about half a mile further at Yallourn in practically unlimited quantities, the only trouble being that the Yallourn coal is extremely friable and contains up to 64 per cent of moisture so that its heating value is only of the order of 3980 B.t u. per lb. The burning of such coal naturally encountered a great many difficulties, and it may be of interest to see how this problem was solved by the engineers in the Antipodes.

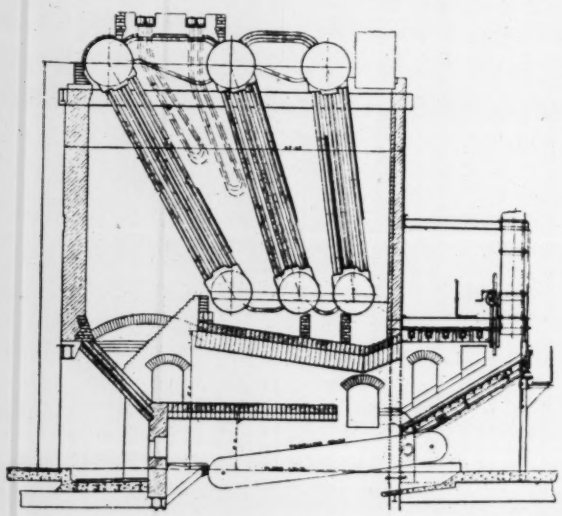


FIG. 1 ARRANGEMENT OF YALLOURN BOILER UNIT EQUIPPED WITH INCLINED SUPPLEMENTARY STEP GRATES

The boiler plant in question was built first to use Morwell brown coal, which was done fairly successfully. The real troubles did not start until the plant was converted to the Yallourn coal. It is obviously necessary to predry it. Moreover the original plant was equipped with chain grates and it was felt from the beginning that when using a coal of such a high moisture content a very much larger combustion chamber than formerly would be required, and that the chain-grate structure would be unsuitable for drying and burning such a moist coal. This proved to be the case. The Commission had a steam plant erected as a temporary source of electrical energy for construction work, and it was there that the preliminary experimental work was done. The plant was equipped with three Babcock & Wilcox boilers, one of which had an underfeed traveling-grate stoker and the other two had chain-grate stokers. The first attempt to predry coal was by providing a louvred drying chute with the coal passing through it on its way from the bunker to the grate. In this chute the coal was dried by the hot flue gases from the boiler. Tests on these drier units indicated that when Yallourn brown coal screened to a maximum size of $1\frac{1}{2}$ in. with only a very small percentage of coal below $\frac{1}{4}$ in. was being used, the conditions were good. Soon, however, the difficulties of screening coal having the Yallourn characteristics became so serious as to make it clear that a change of methods was necessary. The coal was so friable that too great a quantity of fines was created, this being increased by the action of screening, and in turn making screening very difficult. More fines were produced than could be used for briquetting, in addition to which the effect of the fines was to cause the coal to jam in the driers and seriously impede the draft. The decision was that drying by waste fuel gases in a chute drier of the type described was not applicable to the short Yallourn coal.

At about that time it was found necessary to produce more power. An attempt was made to do this by providing a supplementary grate. The first form of apparatus to be used was simply an inclined-grate surface supplementing the chain grate. It was made up of stepped bars and exposed the moist coal to radiant heat and to a limited extent to a transfer of heat by conduction from gases in contact with the coal surface. The angle of the fixed grate, Fig. 1, was such that the coal flowed by gravity in a stream from the chute to the traveling chain grate. The transfer of heat to the incoming coal was not sufficiently rapid to dry off and ignite the surface stream of coal before it reached the combustion zone, but it was sufficient to commence the drying process immediately the coal entered the head of the fixed step grate. In addition to this surface drying there was a degree of heating and drying taking place on the underside of the stream of coal derived from the underburning of the coal lying between the bars of the grate and sheltered from the onward movement of the coal. This action can be readily understood when it is appreciated that, unlike black coal, the Yallourn brown coal when dry will ignite at a temperature of approximately 370 deg. fahr., provided sufficient air is present.

The auxiliary step grates have had quite an appreciable effect on the capacity of the boilers, loads of 74,040 lb. of steam per hour being obtained from the boiler units when burning Yallourn brown coal with the pieces of coal of over $2\frac{1}{2}$ in. size screened out. This evaporation is equivalent to 77.6 lb. of coal consumed per sq. ft. of total grate area per hour, corresponding to a heat liberation of 239,600 B.t.u. per sq. ft. of total grate per hour.

With fixed inclined grates preceding the chain grates, difficulty was experienced when large fluctuations in the size of coal occurred, hence it was felt that a mechanical movement of the inclined grate bars would be advantageous, especially as in addition it would break up the fuel bed, thereby allowing access of air to the pieces of coal below the surface of the coal stream. Preliminary trials on a unit equipped with a mechanical-type predrying grate, working in conjunction with a chain grate, have shown that a mechanical movement facilitates the control of the coal flow down the inclined surface, but have also demonstrated that the increase in drying incidental to the mechanical has not been very marked.

By the time this was accomplished it became necessary to give some thought to trying alternative methods for use in a second

boiler house in connection with extensions to the power station which the increasing demands of the system would shortly require. There were two methods that suggested themselves: (1) Pulverized dried brown coal; and (2) raw brown coal on stepped grates. Preference was given to the latter, and a mechanically operated stepped grate was installed on a boiler.

The most important point to notice about burning brown coal on inclined step grates, whether mechanically moving or fixed, is that the fundamental principle governing the burning of brown coal is fulfilled to a certain extent automatically, viz., the coal in the preheating and drying zone is in a thick bed, while in the combustion zone it is thin. Thus two important functions are performed:

a The major portion of the air is supplied to the thin portion of the fuel bed, that is, to the active portion of the fire.

b A large quantity of semi-dry coal is provided, sufficient to meet the normal fluctuations in the steam demand from a boiler unit without adjustments of fuel-bed thickness and without demanding, in the case of a mechanical type of grate, such close and concurrent attention to stoker speed regulation as is demanded with the horizontal chain grate.

A very important factor in the success of a grate for burning brown coal is that the bars of the grate should be designed to encourage "underburning" to the fullest extent possible. Underburning is the name given to the burning of the coal which accumulates between the bars and which does not pass along at the same speed as the coal itself. This coal, being stagnant, dries readily and ignites, this creating a marked drying effect on the fuel bed. In the case of the older forms of fixed step grates underburning was attended with a serious drawback, inasmuch as it increased the objectionable effects of puffing out of the flame when the coal avalanched. As the puffing out is due to uneven flow of the coal, it is obvious that it will occur mainly in stations where the coal is extremely variable in texture and especially in plants equipped with the older forms of fixed step grates, which are of necessity installed at steep angles. With the advent of the mechanically moving grate with its smaller inclination and regulating devices, it is possible to cause the coal to flow more evenly, with the result that this trouble does not occur in plants using mechanical grates. Advantages of the mechanical-type step grate are its capacity for handling fluctations in coal texture, and the comparative ease with which increasing and decreasing loads can be met.

The basic design of the mechanical step grates installed under one boiler unit at the Yallourn power station makes it possible to control the coal in three different places on the grate surface, with the result that the combustion process is capable of more accurate and efficient control than with other forms of grate. This advantage in combustion control is not obtained without certain disadvantages, as the design of the grate is complicated and more skill on the part of the attendant is demanded. An interesting feature of the design is that the rear section of the grate, which is almost horizontal, permits of adjustment while the unit is in actual operation. It will be noted that a small fixed type of step grate is set so as to receive the discharge of ash and unburned coal from the horizontal moving grates. This fixed grate has a twofold function to perform:

a To burn off any extra large pieces of coal, which, owing to their variable drying characteristics, cannot be burned in the time interval allowed for the burning of the finer-sized coal.

b To burn the fine coal particles which separate out from the gas passing out of the combustion chamber. The particles which lodge on the inclined rear wall of the furnace fall down through holes at the function of the rear inclined arch and this furnace wall.

The small fixed step grate therefore acts as an automatic preventive of coal passing unburnt into the ashpit, and obviates to a large extent the amount of attention necessary when the unit is carrying fluctuating loads and when operating on a variable-sized coal.

The stepped-grate unit is, however, not equipped with a gear-operated variable fuel gate between the drying shaft and the mechanical grate as it was felt that frequent adjustment of the fuel gate would be necessary with a mechanical grate in which the rate of flow of the coal down the grate is principally controlled by the variable speed of the movable parts. The normal fluctuations in demands are therefore made by adjusting the speed of the mechanical actuating device.

Following on the success of the inclined fixed grates when applied to the chain grates, it was decided that any step grate in order to make the most of the space available, should be

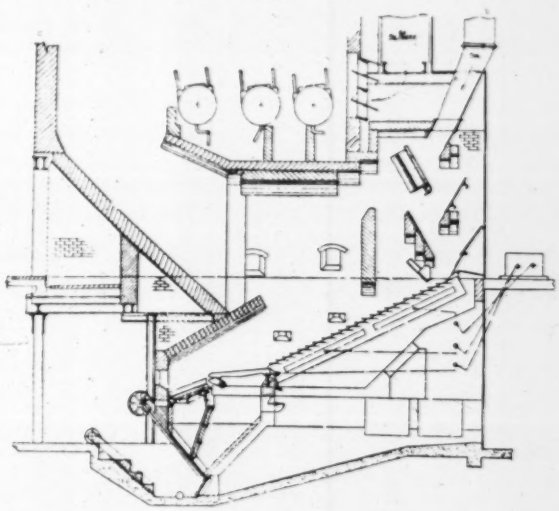


FIG. 2 MECHANICALLY OPERATED STEP GRATE INSTALLED ON BOILER AT YALLOURN POWER STATION

equipped with some form of drying shaft situated inside the combustion chamber. The design of drying shaft adopted is seen in Fig. 2. It consists of a staggered arrangement of firebrick walls set in the combustion chamber at angles such that the coal, during its passage down the drier, is compelled to take a zig-zag path with the result that a mixing action is obtained.

Preliminary trials of this drying shaft and of the mechanical step grates have been made and have shown that it is possible under operating conditions to burn 95.2 lb. of Yallourn brown coal per sq. ft. of mechanical grate, corresponding to a liberation of 294,000 B.t.u. per hr. per sq. ft. of grate. The coal used on these tests was crushed Yallourn brown coal with approximately 10 per cent over $2^1/_2$ in. and 40 per cent under $^1/_4$ in., and containing 64 per cent of moisture. Under operating conditions the unit, which is equipped with both forced- and induced-draft fans, was operated with an air pressure of 1.0 in. of water column on the chamber under the grate of 0.35 in. of water-column suction in the combustion chamber. The trials were made when the unit was operating on cold air before the completion of the air preheater, hence considerably better results are anticipated in the future when hot air under pressure is supplied to the furnace.

It has been found that a positive pressure in the air chamber under the grates substantially increases the capacity of the boiler plants under which is burnt raw brown coal, but in the case of the compartment-type chain grate, positive pressure also introduces a very troublesome situation in the boiler house, inasmuch as large quantities of sparks and dust are blown out from the

clearance spaces between the moving and fixed portion of the grate. With step grates, however, the pressure chamber can be more effectually sealed.

As previously mentioned, in view of the success attained in burning Yallourn raw coal in this trial unit, it is proposed to adopt the same general design for the first section of boiler plant to be installed in the second boiler house at Yallourn. Fig. 3 indicates the proposed arrangement of boiler units. There are to be eight boiler units in the first installment of the new boiler house, but accommodation is being provided for twelve boiler

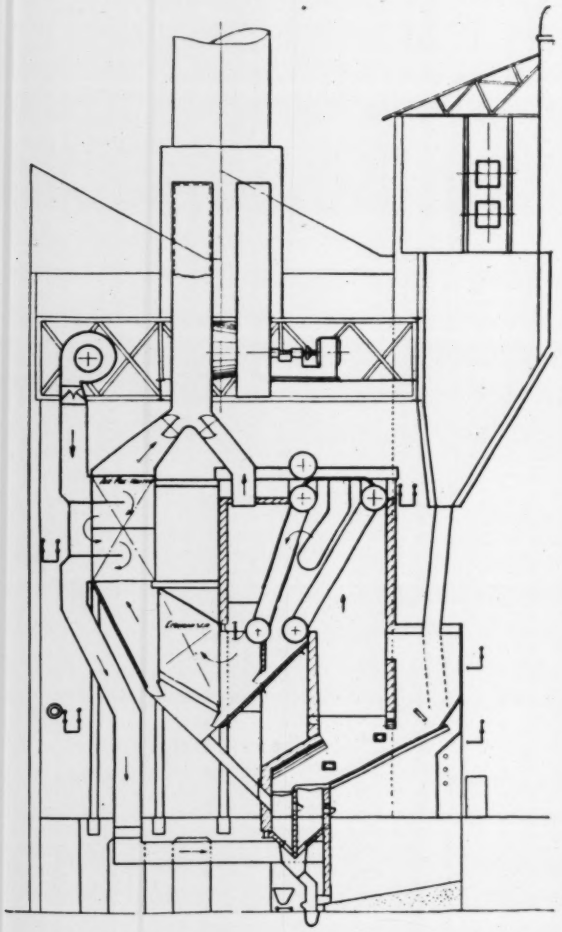


FIG. 3 ARRANGEMENT OF PROPOSED BOILER UNIT FOR THE YALLOURN EXTENSION BOILER HOUSE

units, each with a normal evaporation of 75,000 lb. of steam per hr. from feedwater at a temperature of 280 deg. fahr. into steam at pressure of 270 lb. per sq. in. (gage) and at a temperature of 700 deg. fahr. at the superheater stop valve. The units are to be designed to burn Yallourn brown coal containing 64 per cent of moisture, and will be equipped with mechanical step grates and drying shafts.

An unusual feature in the specification for the new boiler plant is included in the section dealing with performance guarantees of the proposed plant, in that all guarantees of efficiency have been replaced by guarantees of flue-gas temperatures.

The elimination of the usual guarantees of overall boiler-plant efficiency avoids the necessity for an assumption by the manufacturer of the unaccounted-for losses incidental to burning fuel with which there has been so little previous experience. A table in the original article summarizes the results obtained with various forms of apparatus which have been used in the combustion of the Morwell and Yallourn brown coals in the several stages of development. This table shows the size at which low-grade brown coal with a moisture content up to 50 per cent can be burned efficiently, compared with the extreme difficulty of obtaining like proportional results from 64 per cent moisture Yallourn coal of wide textural variability. It further demonstrates that these difficulties can be overcome by the adoption of suitable methods of a reasonably simple character. (*The Electrical Engineer of Australia and New Zealand*, vol. 5, no. 7, Oct. 15, 1928, pp. 235–241, 5 figs., *deA*)

Short Abstracts of the Month

ENGINEERING MATERIALS

Centrifugally Cast Iron Pipe

THE author deals with the work of the Gelsenkirchen Mining Co., which in 1922 started on experimental work based upon the original Briede patent. Briede invented the open and movable pouring spout in 1910, but was it not until 1926 that a commercial plant was put into operation.

As now installed a single casting machine turns out from

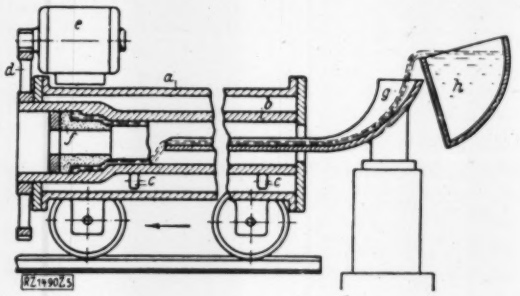


FIG. 1 CENTRIFUGAL PIPE-CASTING MACHINE

(*a*, housing; *b*, rotary mold; *c*, bearing roller; *d*, gearwheel; *e*, motor, *f*, core; *g*, pouring spout; *h*, ladle.)

twenty to forty pipes per hour. Its construction is shown in Fig. 1.

In a housing *a*, see Fig. 1, which also serves as cooling-water jacket, the rotary mold *b* is supported on four rollers *c*. The rotation of the mold is obtained through a gear *d* driven by a variable-speed motor *e*. Prior to casting, a sand core *f* is placed into the head end of the rotary mold, this core serving only to produce the internal shape of the bell. From the opposite side the stationary pouring spout *g* extends into the interior of the mold with a maximum reach to within very near the core *f*. A pouring ladle *h*, so proportioned as to discharge the molten metal in a uniform stream and holding the exact amount of iron required for one pipe, is arranged above the end of the spout *g*.

In operation, the machine is moved to the extreme right-hand position, and the motor started. As soon as the proper speed is attained, a hydraulic cylinder tips the ladle *h*, causing a steady discharge of the metal through the spout into the machine. As soon as the bell portion has been filled, the machine is moved at uniform speed to the left by means of electric or hydraulic power, until the discharge end of the spout is entirely clear of the machine. The combined rotary and lengthwise motion causes the ribbon of liquid metal to coil itself against the inner surface of the mold after the manner of a rope on a drum, centrifugal

force compelling it to spread out in the form of a cylinder of uniform wall thickness.

Owing to rapid solidification of the liquid metal in the iron mold, it is upon the accuracy and durability of this part that the success of the process largely depends. In addition to being unaffected by heat, the mold must above all be resistant to deformation during pouring. Great difficulties had to be overcome before this twofold condition was fulfilled, particularly in regard to long pipes. Today, pipes of up to a diameter of 100 mm. (4 in.) are made in lengths of 4 m. (13 ft.), while sizes above 100 mm. (4 in.) are produced up to 5 m. (16 ft.) long.

Extensive tests on this kind of pipe are reported in the original article. The Gelsenkirchen Works guarantee for their products a tensile strength of 25,000 to 28,000 lb. per sq. in., and, when required, use this increased strength to obtain a corresponding reduction in weight.

Tests dealing with the resistance of the pipe to corrosion were conducted in 1927 by Prof. Piwowarsky at the Metallurgical Department of the Aachen Technical University.

It is claimed that centrifugally cast pipe showed an increase of corrosion resistance of from 10 to 21 per cent. This is ascribed to the extremely fine distribution of the graphite in the centrifugal pipe. Tests were also conducted on the growth of cast iron in such pipe, which is of particular interest in connection with its use in feedwater preheaters. It is claimed that centrifugal pipe is practically free from growth subsequent to being cast. (C. Pardum, Gelsenkirchen, in *Engineering Progress*, vol. 9, no. 11, Nov., 1928, pp. 305–309, 8 figs., *d*)

FUELS AND FIRING (See also Railroad Engineering: Transport of Pulverized Fuel)

Railroad Transportation of Pulverized Coal

THE question as to who should pulverize coal, i.e., the mine or the user, is one that must be decided according to the circumstances of the case. There is, however, a good deal of coal that can be sold in pulverized form by the mine, and the question of its transportation therefore becomes of importance. A number of types of cars for this purpose have been developed in Germany. The earliest and simplest consisted of a flat car on which were installed three plate-iron containers, each of 10 cu. m. capacity (353 cu. ft.).

In the design of pulverized-coal cars attention should be paid to the fact that in the first place all moisture must be very carefully kept out. In the second place, pulverized coal is easily delivered to the car, as it flows through a pipe practically like water. In the car, however, during the trip, it is subjected to shaking, which, under certain conditions, may result in the particles of coal joining together and forming a practically solid mass, which makes the discharge of the coal from the car or container most difficult. This applies particularly to fat coals. In the case of the individual container very large openings can be provided at the bottom and a complete discharge of coal can be assured by making the container so that it will have a small taper upward.

In the transportation of brown coal the matter of coalescence of the particles is not so bad. In this case the coal is carried in a container which occupies the whole length of the car and looks somewhat like a short, fat sausage. Its production requires, however, somewhat expensive boiler-shop work. The delivery of the coal from the car is carried out under 2 atmos. (28.4 lb. per sq.in.) air pressure, which, among other things, means that the container must be equipped with a manometer and safety valve.

Recently a new type of car has been developed in which coal is carried in vertical containers but is discharged not by gravity but by air pressure or suction. Several types of such cars have been provided. The 2 atmos. gage pressure appears to have become quite standard for this purpose. In one case three vertical containers are provided. These containers are reinforced by steel-plate interconnecting members welded to the containers themselves and the frame of the car. In this way the stiffness of the longitudinal members is increased, while the weight of the containers themselves can be slightly reduced.

An interesting design is shown in Fig. 2 where four segmental containers are used set one against the other. Because of the fact that each one represents an independent unit, all the advantages of the previous types are preserved and yet a very stiff construction occupying the minimum of space is secured. Another illustration in the original article shows the same idea in a modified form.

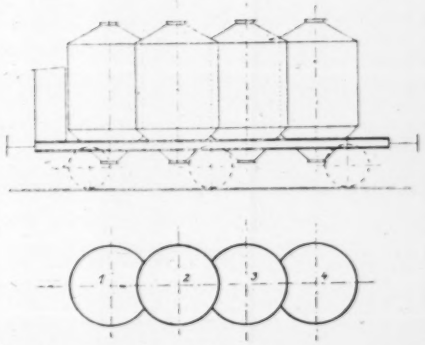


FIG. 2 A POWDERED-COAL CAR OF 80 CU. M. CAPACITY, BUILT BY THE SIEGEN RAILWAY SUPPLY CO., SIEGEN, GERMANY

While only a few years ago the problem of transportation of powdered coal appeared to be a very difficult one, it may be said now that all the mechanical troubles have been eliminated and any kind of powdered coal can be transported safely and delivered to destination dry. (Graduate Engr. Bondy in *Fördertechnik und Frachtverkehr*, vol. 21, no. 22, Oct. 26, 1928, pp. 406–408, 7 fig., *d*)

HYDRAULICS

The Propeller-Type Turbine at the Falls of Ohio Plant, Louisville, Ky.

THIS turbine is of interest because it contains the first five-bladed runner ever built. The propeller type has certain advantages which are discussed in detail in the present paper. Of these only the following will be mentioned.

The Louisville wheel has a speed of 100 r.p.m. and wheelmakers were willing to guarantee satisfactory operation of units running at 106 and 112 r.p.m. The Keokuk unit has 30 ft. head for about the same output as the Louisville and runs at a speed of about 58 r.p.m. The main effect of this increase in speed is the reduction in the size of the generators. The Keokuk generators having 62 pairs of poles are 34 ft. in diameter, while the Louisville generators with 36 pairs of poles have diameters of 26 ft. There is therefore a considerable saving in the cost of the electrical equipment, and furthermore the entire building from foundation to roof, a total vertical distance of 150 ft., can be made 8 ft. narrower. As the building at Louisville is 508 ft. long, it is estimated that the saving in cost on account of the adoption of this type of runner amounted to 15 per cent, while the total reduction in cost per kilowatt-hour made possible by the use of the propeller type of unit was about 25 per cent.

In fact, if the actual cost had been increased by 25 per cent, as

would have been the case with other types of runners, it is very probable that the project would not have been undertaken.

Another question, that of flotation, was involved, but this is only indirectly concerned with the question of the runner. (H. G. Roby, Hydraulic Engr., Byllesby Engineering and Management Corporation, Chicago, in a paper presented before the W.S.E. on March 26, 1928, and published in the *Journal of the Western Society of Engineers*, vol. 33, no. 11, Nov., 1928, pp. 573–580 and discussion on pp. 580–581, *g*)

Adjustable Propeller Runners at Chippewa Falls

AN INTERESTING type of propeller runner has been recently installed in the generating unit at the new Chippewa Falls plant of the Northern States Power Company on the Chippewa River in Wisconsin. The water wheels are of the adjustable-vane propeller type of 5000-b.hp. size, built by Allis-Chalmers and operating under a maximum head of 29.6 ft. at 138 r.p.m., with a specific speed of 140. Each runner has four vanes, the angle of which is adjusted to meet varying water conditions by a hand-operated mechanism incorporated in the large hub on the wheel. While it is necessary to shut down the unit when changing the vane setting, this is not considered a serious disadvantage. The unit is controlled entirely by one operator from a central control board, assisted by a floor man whose only duties are to inspect the equipment and controls.

The arrangements of buses and electrical equipment is one of the most interesting features of the plant. The control equipment is designed for control with automatic starting and shutdown features. The Chippewa Falls plant is operated in conjunction with another plant at Wissota, and since Wissota uses first the water which passes through Chippewa Falls, the method of operation is dictated by the load and by water conditions at Wissota, because there is no pondage in the Chippewa Falls reservoir. (*Power Plant Engineering*, vol. 32, no. 23, Dec. 1, 1928, pp. 1276–1278, 6 figs., *d*)

MARINE ENGINEERING

Self-Unloading Vessels

THE primary purpose of the self-unloading vessel is to provide a flexible transportation unit that can deliver material economically and rapidly to any water-front point without dependence on or waiting for the operation of shore machinery. Self-unloading freight boats are also valuable for the handling of rough, abrasive materials, such as broken stone, which are slow and expensive to handle with digger-bucket equipment. The saving in ship's time is also a factor in self-unloading-boat development, especially in short-haul operation. At times the use of a self-unloader permits delivering material at a point nearer to the ultimate point of consumption than would otherwise be the case. Furthermore the self-unloader vessel with a large number of cargo compartments can approximate car delivery service given by railroads in that it can deliver smaller quantities at low water-transportation rates without the necessity of the consumer supplying equipment to avail himself of the use of water transportation.

While the self-unloader boat is as yet undeveloped for inland waterways, a start has been made. There is now being built a shallow-draft twin-screw Diesel-engined self-unloading barge designed for operating under low bridge clearances for use on the Chicago River and Drainage Canal. This barge is also equipped with sand-dredging pumps and can produce her own cargoes by pumping sand and gravel deposits, screening and washing sand, and can then deliver them to any desired quantity along the water front.

There is an advantage in installing the equipment on the ship instead of the dock, because of possible changes that may be encountered in the movement of materials. Such changes might render the dock equipment useless due to other and better methods of delivery, or other available sources of supply of the materials. The self-unloading boat, being a movable flexible unit, is not tied down to one operation or location and can be shifted without loss into other fields of usefulness. The development of the self-unloader boat on the Great Lakes rapidly replaced the schooner and barge system of delivery, and it has placed the consumers, cities, and industries handling small annual tonnages practically on a par, as far as transportation and discharging cost are concerned, with the large-tonnage users of these materials. In this way it is performing a great service to water-front customers, who heretofore were obtaining little benefit from their proximity to the supposedly low-cost water-transportation routes.

The self-unloading boat has eliminated the difficulties of the small dock man's operation due to inadequate and intermittently used dock machinery, and it saves the labor of stevedoring in unloading. Another advantage of the self-unloading ship is the saving in abuse to the ship's hatch and cargo-floor structure.

As regards maintenance, it is stated that it has been found from actual experience that unloading rigs properly built and designed do not cost on an average any more for maintenance than dock equipment, in fact possibly less.

The author describes briefly his own system, known as the sub-cargo scraper method, which has been installed on twelve vessels in the last five years with unloading capacities from 400 to 2000 tons per hour.

Briefly, the particular type of unloading arrangement referred to consists of two longitudinal tunnels built into the bottom of the regular hold, with a drag scraper operating forward and backward in each tunnel. The tops of the tunnels, the space between tunnels, and the sides of the hold are hoppered enough to make them self-cleaning. Hinged doors along both sides of each tunnel can be released, permitting the cargo to gravitate into the tunnels.

The scraper in each tunnel operates on a system of cables. When the scoop is being pulled backward, the rear is lifted, causing it to ride over the material which has fallen through the sides. As the scoop is pulled forward, it digs down, pushing the material forward on the smooth steel floor until it is discharged on an inclined belt conveyor in the front of the boat. As the material in the tunnel is scraped forward, new material slides into the tunnel ready for the next trip of the scoop.

The inclined belt conveyor elevates and discharges the material on the boom belt conveyor on the deck. This conveyor can be swung out over the side of the boat and raised or lowered to discharge over a wide area as may be necessary or convenient. (Leatham D. Smith, Pres., Leatham D. Smith Dock Co., Sturgeon Bay, Wis., in a paper before the convention of Stephens-Adamson Mfg. Co., Engineers, at Aurora, Ill.; abstracted through *Marine Review*, vol. 58, no. 12, pp. 49–51, 2 figs., *d*)

MEASURING INSTRUMENTS

A One-Motion-Control Viscosimeter

THE Saybolt method of measuring viscosity has become practically standard in this country because of its simplicity. However, it is accurate only if the test is made in a careful and expert manner, as it is necessary to maintain the bath at a constant temperature and in addition to coordinate the removal of the cock from its position and the starting of the stop watch as well as its stopping when the bottom of the meniscus of the oil reaches the mark on the neck of the receiving flask. In some places elaborate devices to reduce errors due to the personal

equation in carrying out the test have been introduced. This has not yet been done universally because of the high cost of these devices.

The instrument referred to here, which is built by the Teschner-Myers Co., Inc., is so arranged that one motion starts the flow of oil and the stop watch simultaneously, and another motion likewise stops them. Means are also provided to maintain practically automatically the temperature of the bath. (*Instruments*, vol. 1, no. 11, Nov., 1928, pp. 493–494, 1 fig., *d*)

MOTOR-CAR ENGINEERING

The Rutzebeck Heavy-Oil Injection Device

THIS device has been designed to take the place of the carburetor on an ordinary motor-car engine, and it is claimed that it will permit starting and running both on gasoline and heavy oil, eliminate the possibility of carburetor fire, and allow the engine to function in any position, as, for example, upside down. It is stated that the device has been successfully applied to a 1923 four-cylinder Dodge Brothers car (with increased compression, however).

In brief, the Rutzebeck device (Fig. 3) consists of small diaphragm pumps, one of which is mounted on the combustion head of each cylinder, and mouthpieces or injection nozzles which are likewise fitted into each combustion chamber, or alternately one mouthpiece is located centrally inside the induction manifold. The ordinary carburetor is removed from the engine when this device is fitted.

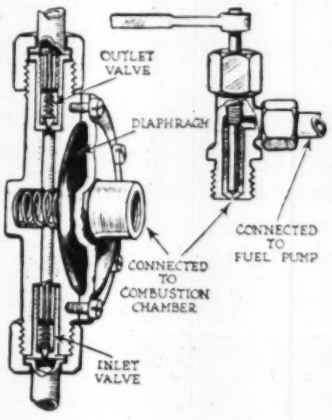


FIG. 3 THE RUTZEBECK FUEL-INJECTION DEVICE

Each pump consists of a brass casing provided with suction and delivery valves and contains a bronze or steel diaphragm, and when the explosion takes place in the cylinder it causes the diaphragm to move so that a small amount of fuel is expelled through the delivery valve and taken by a suitable pipe to the mouthpiece next in order of firing. The maximum movement of the diaphragm is approximately 0.5 mm. (0.02 in.) and this is sufficient to raise fuel to a height of approximately 6 ft., if required, so that the position of the fuel tank on the chassis is, on this account, immaterial and the vacuum feed tank is therefore eliminated.

The mouthpieces or injection nozzles consist of a housing containing an adjustable needle valve and seating of special shape, and this is screwed direct into the combustion chamber. Movement of all the needle valves is controlled by the throttle lever or accelerator pedal, which is also connected to a air shutter fitted to the normal induction manifold. It is only necessary to move the needle valve through an angle of 90 deg. to pass from the fully closed to the fully open position, and this opening only raises the needle valve 0.125 mm. (0.005 in.) from the aperture in its seating, the actual hole being 0.4 mm. (0.016 in.) in diameter.

It is partly owing to the small orifice of the valve that the successful working of the diaphragm pump is due, for the fuels contained in the pump and delivery pipe, and the resistance of this small orifice to the passage of the fuel, produce a cushioning effect, which allows the diaphragm to withstand the force of explosion in the cylinder. The return spring is used solely to insure a quick movement of the diaphragm back to its normal position, so as to enable it to draw a sufficiency of fuel into the casing. (*The Autocar*, vol. 61, no. 1725, Nov. 23, 1928, p. 1187, 2 figs., *d*)

RAILROAD ENGINEERING (See also Fuels and Firing: Railroad Transportation of Pulverized Coal)

Transport of Pulverized Fuel

THE firm of Cammell Laird & Co., Ltd., of Nottingham, England, has designed a special car for the conveyance of pulverized fuel or natural coal dust. This car consists of two special containers mounted on a four-wheeled underframe. The containers are cylindrical, built up of steel plates, and are gun-shaped at the top and bottom. A hinged manhole cover is provided through which the container is filled. This is held down by hinged clamp bolts, and a special packing ring is provided to make the cover airtight. The outlet pipe connects to the bottom of the container, the two pipes joining into one connection which is situated at one end of the car beneath the underframe, and is provided with a screwed cap. Compressed air is used for discharging the car through a system of piping and nozzles. The nozzles in each container are controlled by three valves. One valve operates a pair of nozzles about midway in the container, one the special patent plate blower near the bottom, and a third, a rifle jet which protrudes into the opening of the discharge pipe at the base of the container. The car is filled through the manhole. (*Modern Transport*, vol. 20, no. 506, Nov. 24, 1928, p. 13, 2 figs., *d*)

REFRIGERATION

Ammonium Chloride as a Refrigerating Agent

THE author deals particularly with what he refers to as the "eutectic" method, where the eutectic solution is used in a container called an "insert," is hermetically sealed, and is frozen inside the insert in a brine tank. When frozen solid, the insert is taken out, wiped, and its refrigerating effect used. There is no dripping associated with the use of inserts, and no possibility of contamination of goods to be preserved; further, they are very easily handled as compared with ice and salt.

When it comes to the selection of the material for the eutectic mixture, it has been found that ammonium chloride eutectic has the greatest refrigeration effect for its weight and is approximately six times as efficient in maintaining a temperature of 10 deg. fahr. as mixed ice and salt.

To determine its advantages an experimental tricycle and inserts were made and a number of tests carried out. These dealt primarily with keeping ice cream cool, but in addition to this an insulated cabinet has been evolved in which inserts are used as a refrigerant for outside catering. The tests are said to have been successful and are given in the original article in the form of a curve. (Dr. L. H. Lampitt and P. Bilham in *Cold Storage and Produce Review*, vol. 31, no. 368, Nov. 15, 1298, pp. 359–361, 2 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Tool-Holder Shanks and Tool-Post Openings

THE proposed American Standard for Tool-Holder Shanks and Tool-Post Openings has been completed by the Sectional Committee on the Standardization of Small Tools and Machine-Tool Elements, and is now passing through the final stages necessary for its approval as an "American Standard."

The Sectional Committee was organized in September, 1922, in accordance with the procedure of the American Standards Association (formerly the A.E.S.C.) under the joint sponsorship of the National Machine Tool Builders Association, the Society of Automotive Engineers, and The American Society of Mechanical Engineers. Since its organization it has undertaken the standardization of twelve projects and completed one standard on T-Slots and Their Cutters. The proposed standard for Tool Holders and Tool-Post Openings is reproduced herewith for the information of our readers. The A.S.M.E. would welcome criticism and comment of this proposal from any and every source. Letters should be addressed to C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

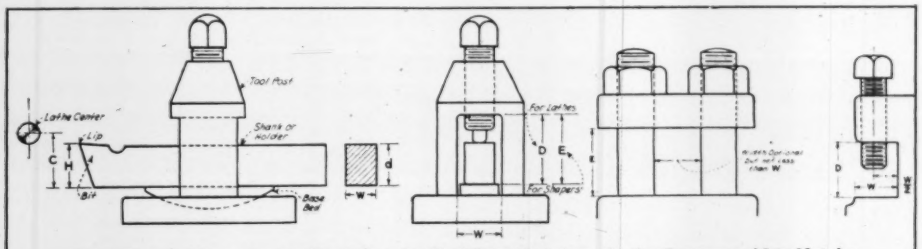


Table No. 1. Dimensions of Tool Shanks, Tool Post Openings, Lathe Center and Lip Height

Tool Number	Shank Section			Lathe Opening			Planer and Shaper Opening			Lathe Center Height			Lip Height	
	Max.	Nominal	Max.	Min.	Nominal	Min.	Min.	Nominal	Min.	Max.	Nom.	Min.	Max.	Min.
	d	dxw	w	D	DxW	W	E	ExW	W	C	C	C	H	H
00	0.85	¾ x ⅜	0.40	1.27	1⅜ x ½	0.49	1.04	1 1/16 x ½	0.49	0.93	⅞	0.85	0.85	0.75
0	0.99	⅞ x 7/16	0.48	1.48	1½ x 9/16	0.57	1.19	1¼ x 9/16	0.57	1.09	1	0.99	0.99	0.87
1	1.15	1 x ½	0.56	1.72	1¾ x 11/16	0.68	1.38	1 7/16 x 11/16	0.68	1.26	1 3/16	1.15	1.15	1.00
2	1.34	1¼ x 5/8	0.67	2.00	2 x 13/16	0.81	1.61	1 5/8 x 13/16	0.81	1.47	1 3/8	1.34	1.34	1.25
3	1.56	1½ x ¾	0.80	2.34	2⅜ x 1	0.96	1.87	1⅞ x 1	0.96	1.72	1 9/16	1.56	1.56	1.50
4	1.81	1¾ x ⅞	0.95	2.71	2¾ x 1 3/16	1.14	2.17	2 3/16 x 1 3/16	1.14	1.99	1 13/16	1.81	1.81	1.75
5	2.11	2 x 1	1.13	3.16	3⅛ x 1 3/8	1.35	2.53	2 9/16 x 1 3/8	1.35	2.32	2⅛	2.11	2.11	2.00
6	2.43	2½ x 1 1/4	1.34	3.65	3 11/16 x 1 5/8	1.61	2.92	3 x 1 5/8	1.61	2.67	2 7/16	2.43	2.43	2.25
7	2.86	2¾ x 1½	1.60	4.29	4¼ x 1 7/8	1.91	3.43	3 7/16 x 1 7/8	1.91	3.15	2⅞	2.86	2.86	2.75
8	3.34	3 x 1¾	1.90	5.00	5 x 2¼	2.27	4.00	4 x 2¼	2.27	3.67	3⅜	3.34	3.34	3.00
9	3.87	3½ x 2	2.26	5.80	5⅞ x 2¾	2.70	4.64	4¾ x 2¾	2.70	4.25	3⅞	3.87	3.87	3.50
10	4.50	4¼ x 2½	2.69	6.75	6¾ x 3¼	3.21	5.40	5½ x 3¼	3.21	4.96	4½	4.50	4.50	4.25
11	5.25	5 x 3	3.20	7.87	7⅞ x 3⅞	3.84	6.30	6⅜ x 3⅞	3.84	5.77	5¼	5.25	5.25	5.00

All dimensions in inches.

Graphic Symbols for Telephone and Telegraph Use

THE Proposed American Standard for Graphical Symbols for Telephone and Telegraph Use is the fourth set of symbols to be submitted to the Sponsor Bodies by the Sectional Committee on Scientific and Engineering Symbols and Abbreviations. This proposal was prepared by Sub-Committee No. 7 on Electrotechnical Symbols Including Radio.

This Sectional Committee, it will be recalled, was organized in January, 1926, under the procedure of the American Standards Association (formerly the A.E.S.C.) as a culmination of a series of efforts on the part of the A.S.C.E., A.S.T.M., A.I.E.E., S.P.E.E., A.S.M.E., and other national organizations. Joint sponsorship was accepted by the following Societies: The A.A.-A.S., A.S.C.E., A.I.E.E., S.P.E.E., and the A.S.M.E. Twenty-nine national societies and associations have appointed official representatives on the Sectional Committee of which Dr. J. Franklin Meyer, of the Bureau of Standards, is Chairman; Dr. Sanford A. Moss, Thompson Research Laboratory, Vice-Chairman; and Preston S. Miller of the Electrical Testing Laboratories, Secretary.

The officers of the Sub-Committee on Electrotechnical Symbols Including Radio are: J. Franklin Meyer, Chairman, C. H. Sanderson, Secretary. The Sub-Group which originated the proposal is composed of the following personnel: William E. Farnham, Chairman, American Telephone and Telegraph Company, Herbert W. Drake, Western Union Telegraph Company, W. J. Heard, Bell Telephone Laboratories, Inc., L. F. Shea, New York, New Haven & Hartford Railroad Company, and Authur Bessey Smith, Automatic Electric, Incorporated.

This proposed standard for graphical symbols for telephone and telegraph use having been approved by vote of the Sectional Committee, is now before the five Sponsor Societies for approval and submission to the A.S.A. for approval and designation as an American Standard. Accordingly, as one step in the A.S.M.E. consideration of the standard, this notice is published in MECHANICAL ENGINEERING and a few of the typical symbols are reproduced on page 158 for the information of our readers. Those specially interested in this subject may secure a copy of the complete report by addressing C. B. LePage, Secretary of the A.S.M.E. Standardization Committee, 29 West 39th Street, New York, N. Y. It is requested that criticism or comment on this proposal be sent to the same address.

(Continued on page 158)

Engineering and Industrial Standardization

A.S.M.E. Standardization Committee

THIS Committee held its quarterly meeting on December 6 with all five of its members present. William S. Monroe, president, Sargent and Lundy Company, attended on invitation of Chairman C. P. Bliss, since he has been appointed to fill the vacancy made by the expiration of A. M. Houser's term of membership. Prof. C. P. Bliss was reelected chairman for the coming year, and his nomination for reappointment as one of the A.S.M.E. representatives on the American Standards Association was approved.

A large amount of routine business was disposed of first, and then the Committee considered a number of items of new business. Among these were (*a*) the proposed study courses in standardization, and (*b*) the most satisfactory time and place for Standards Committee meetings.

The successful experiment of the Cleveland Engineering Society, with which the A.S.M.E. is affiliated, in the field of study courses for local groups in standardization has attracted the attention of the A.S.M.E. Standing Committees on Local Sections and Standardization, and at the direction of these committees a considerable amount of information and data on this subject has been collected.

Both committees have gone even further. At the May, 1928, meeting of the A.S.M.E. Council a joint resolution was presented which called for a special appropriation of $500 to cover the cost of developing material for such a course of lectures and study, and its publication in a form convenient for the use of the A.S.M.E. Local Sections and other local groups of engineers and mechanics. This appropriation is available for use during the present fiscal year, so an earnest effort will be made to complete this job before the fall of 1929.

Safety Committees

THE meeting of the A.S.M.E. Safety Committee was held during the week of December 3, Col. John Price Jackson presiding. It was reported that the liaison representatives of the National Safety Council and the A.S.M.E. were now functioning and in close touch with the Local Safety Councils of the National Safety Council and the A.S.M.E. Local Sections and the Student Branches of the A.S.M.E. The Committee voted to request all authors writing papers to be read before the Society to include as many safety features as possible. George E. Sanford safety engineer of the General Electric Company, Schenectady, N. Y., was elected chairman of the Standing Committee for 1929.

A conference of Sub-Committee Chairmen of the Sectional Committee on a Safety Code for Conveyors and Conveying Machinery with Chairman Newman of the Sectional Committee was held on Tuesday, December 4. It was reported that Sub-Committee No. 3 on Gravity Conveyors and Chutes, Live-Roll Conveyors, C. A. Paul of the Mathews Conveyor Company, Ellwood City, Pa., Chairman; and Sub-Committee No. 4 on Spiral and Drag or Scraper Conveyors, C. H. Newman, secretary of the Society of Terminal Engineers, New York, Chairman, each have a section of the code ready for general distribution for criticism and comment. Sub-Committee No. 5 on Cable Conveyors, Harry A. Roe, chief engineer of Sauerman Brothers, Inc., Chicago, Ill., Chairman, also held a meeting during A.S.M.E. Annual Meeting week and discussed its preliminary proposal.

Drawings and Drafting-Room Practice

DURING the past year the Sectional Committee on the Standardization of Drawings and Drafting-Room Practice, for which the Society for the Promotion of Engineering Education and the A.S.M.E. are joint sponsors, has made considerable progress in the development of this project. All of its six committees have held meetings and have framed proposals. Most of these have been duplicated and have been broadly distributed for criticism and comment.

Sub-Committee No. 2, on Method of Indicating Dimensions, held a meeting on December 5 and discussed at length a proposal which had been drafted by its chairman, Edmund B. Neil, manager, Research Department, *Automotive Industries*, Philadelphia, Pa., after a careful study of the practices in force in many industrial plants in this country.

Sub-Committee No. 3, on Lettering, is now summarizing the returns from a questionnaire which was sent to 878 industrial firms in this country. T. G. Crawford, supervisor of drafting of the General Electric Company, is chairman of this Committee.

Sub-Committee No. 4, on Layout, in January, 1928, mailed a chart indicating the proposed standard of arrangement of views for mechanical drawing which employed the third angle of projection. It requested comment on its proposal and now reports a practically unanimous approval of its recommendation. F. G. Wolff, assistant to general mechanical engineer of the American Car and Foundry Company, is temporary chairman.

Sub-Committee No. 5, on Line Work, is especially active and under the leadership of Samuel Ketchum, mechanical engineer of the Treadwell Company, New York, has sent out in succession three draft proposals. It also held a meeting during the week of December 3 and added considerably to the material originally proposed. The revised report will soon be available for further criticism and comment.

Sub-Committee No. 6, on Graphical Symbols on Drawings. G. H. Drake, chairman of the Standardization Committee of the National Association of Master Plumbers of the U. S., is chairman of this Sub-Committee. This Committee was organized to develop first the proposal for standard graphical symbols developed by the National Association of Master Plumbers. Copies of this proposal have been broadly distributed for criticism and comment, and it is now being carefully considered by the American Institute of Architects. This Sub-Committee has before it also a series of graphical symbols proposed by the American Society of Heating and Ventilating Engineers. This Sub-Committee is to confine its activities to graphical symbols in use in the mechanical field while Sub-Committee No. 7 on Electrotechnical Symbols and Abbreviations, including Radio, of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations will complete the standardization of graphical symbols in the electrical field.

Scientific and Engineering Symbols and Abbreviations

IN ITS Sustaining Members' Bulletin of December 20, 1928, the American Standards Association published in full the following report prepared by Preston S. Millar, Secretary of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations. The work of this Committee is of general

interest to our readers and incidentally we desire to compliment the Committee on the good progress it has made to date.

Sub-Committee No. 1—On Symbols for Mechanics, Structural Engineering, and Testing Materials. Under date of October 13, copies of a paper under the title "Report of Technical Nomenclature," by Dr. John T. Faig, presented before the Society for the Promotion of Engineering Education in May, 1928, were distributed to all members of the Sectional Committee for criticism and suggestion, leading presumably to the formulation of a report of the Sub-Committee. It is hoped that with comment which may reach Dr. Faig as a result of this distribution, Sub-Committee No. 1 may be able to present at an early date its recommendations as to symbols to be adopted in this field.

Sub-Committee No. 2—On Symbols for Hydraulics. Report of the Sub-Committee having been approved by the Sectional Committee, it was submitted to the sponsors with due formality under date of August 2, 1928. It has been approved by the A.S.A.S., the A.I.E.E., the A.S.C.E. and the S.P.E.E. Some objections have been put forward by a member of the A.S.M.E. Standards Committee which are now in the hands of Professor Russell's Sub-Committee for reconsideration. Pending decision, the A.S.M.E. is withholding action. This matter is being followed up from the Secretary's Office with a view to securing the necessary sponsorial approval from the A.S.M.E.

Sub-Committee No. 3—On Symbols for Heat and Thermodynamics. The report of this Sub-Committee in preliminary form having been circulated for criticism and suggestions and having been the subject of action by a committee of the I.E.C., is now being put into type through the good offices of the A.S.M.E. It will be circulated shortly with letter-ballot to members of the Sectional Committee.

Sub-Committee No. 4—On Symbols for Photometry and Illumination. This Sub-Committee has prepared a report embodying a revision of the portion dealing with symbols of the present American Standard Illuminating Engineering Nomenclature and Photometric Standards. In this revision the Sub-Committee has endeavored to take advantage of suggestions received from other sub-committees. The report is now being distributed to the Sectional Committee members for criticism.

Sub-Committee No. 5—On Aeronautical Symbols. Report of the Sub-Committee having been duly approved by the Sectional Committee, was transmitted to the five sponsor organizations August 14, 1928. Sponsorial approval was received from four of them in September and October and from the fifth in November. This report has therefore been transmitted to the A.S.A. for adoption as a Tentative American Standard.

Sub-Committee No. 6—On Mathematical Symbols. Report of this Sub-Committee was approved by the A.S.A. as an American Standard in January, 1928. (This report is now available in pamphlet form from the A.S.M.E.)

Sub-Committee No. 7—On Electrotechnical Symbols, Including Radio. The report of Sub-Group No. 1 on Letter Symbols for Electrical Quantities having been subjected to the several necessary steps of approval, was transmitted to the five sponsor societies with approval of the Sectional Committee on July 31, 1928. Sponsorial approval has been received from all of the sponsors and the report has been transmitted to the American Standards Association for adoption as an American Standard.

The report of Sub-Group No. 6 on Graphical Symbols for Telephone and Telegraph Use has been adopted by formal letter-ballot by the members of the Sectional Committee and has been forwarded under date of November 21, 1928, to the sponsors for approval. (See page 156.)

Reports of Sub-Groups Nos. 2, 3, 4, and 5 have not yet reached the Secretary's Office. This is being followed up through the Chairman of Sub-Committee No. 7.

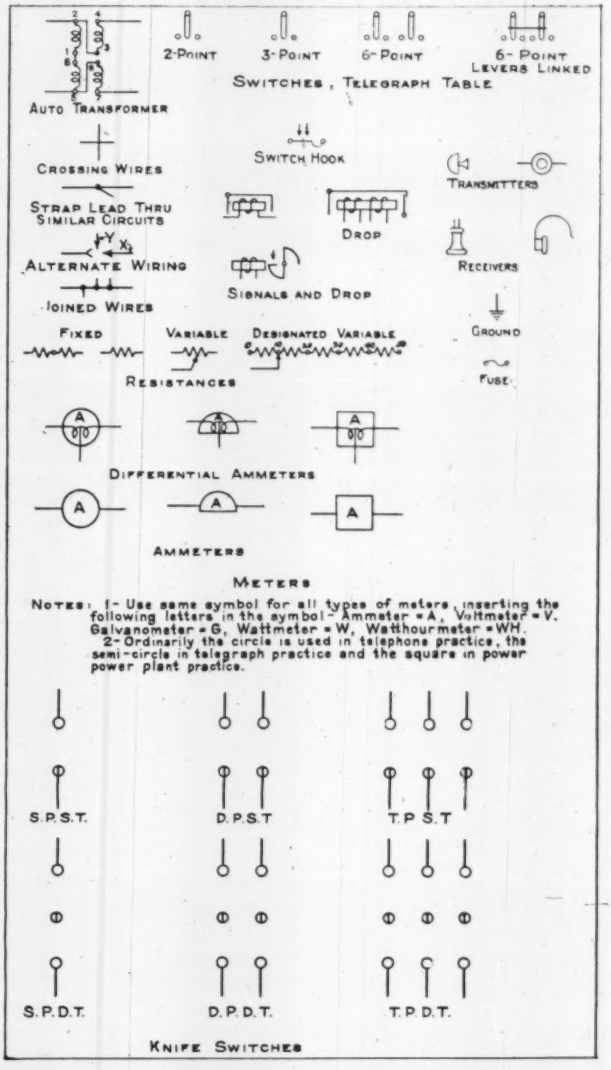
Sub-Committee No. 8—On Navigational and Topographical Symbols. The work of this Sub-Committee was greatly delayed due to a question of policy as between the civilian and military members of the Sub-Committee. The Sub-Committee, however, is now in position to proceed under good augury. A report which will be distributed for criticism and suggestions are due from the Sub-Committee in the very near future.

Sub-Committee No. 9—On Abbreviations for Scientific and Engineering Terms. A proposed report of this Sub-Committee has been placed in type by the A.S.M.E. and has been distributed to the members of the Sectional Committee, to editors of technical journals, to technical societies, and to other interested individuals for criticism and suggestions. The response from this distribution, has indicated much difference of opinion, which may retard the submission of an approved report.

Conclusion. Redoubled activity on the part of sub-committees which have not completed their tasks is required if this Sectional Committee is to attain its goal of completion of work during the current year.

Graphic Symbols for Telephone Use

(*Continued from page 156*)



TYPICAL SYMBOLS FROM THE PROPOSED STANDARD FOR TELEPHONE AND TELEGRAPH USE

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

During the past two years the Boiler Code Committee has received and acted upon a number of suggested revisions which have been approved for publication as addenda to the Code. These are published below, with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and comment thereon from any one interested therein. Discussions should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

After 30 days have elapsed following this publication, which will afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as an addition to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type.

PAR. P-186. REVISED:

P-186. *Welded Joints.* The ultimate strength of a joint which has been properly welded by the forging process, shall be taken as 35,000 lb. per sq. in., with steel plates having a range in tensile strength of 45,000 to 55,000 lb. per sq. in. Autogenous welding may be used in boilers in cases where the stress or load is carried by other construction which conforms to the requirements of the Code and where the safety of the structure is not dependent upon the strength of the weld. Joints between the doorhole flanges of furnace and exterior sheets may be butt or lap welded by the fusion process, provided these sheets are stayed or otherwise supported around the doorhole opening and provided the distance from the flange to the surrounding row of stays or other supports does not exceed the permissible staybolt pitch as per Par. P-199. If such joints are lap welded the exterior-sheet flange should preferably be placed on the outside or next to the door opening and the firebox-sheet flange on the interior next to the water. Autogenous-welded construction may be used in lieu of riveted joints in the fireboxes of internally fired boilers, provided the welds are between two rows of staybolts, or in the case of flat surfaces the weld is not less than one-half of a staybolt pitch from the corner.

ELECTRIC RESISTANCE BUTT WELDING, WHERE THE ENTIRE AREA IS WELDED SIMULTANEOUSLY, MAY BE USED AND THE ULTIMATE STRENGTH OF THE JOINT TAKEN AS 35,000 LB. PER SQ. IN. AS IN THE CASE OF FORGE WELDING, OR IF THE FOLLOWING PROVISIONS ARE MET, IT MAY BE GIVEN A HIGHER RATING THAN FOR FORGE-WELDING, UP TO 100 PER CENT OF THE MINIMUM TENSILE STRENGTH OF THE MATERIAL:

A—THE STEEL USED SHALL CONFORM TO THE CODE SPECIFICATIONS FOR THE PARTICULAR SERVICE TO WHICH THE PART IS TO BE APPLIED.

B—AN AUTHORIZED INSPECTOR MAY DEMAND A TEST OF ANY OF THE WELDED ARTICLES HE MAY SELECT FOR THE PURPOSE, AND, IF AFTER WITNESSING SUCH TEST, HE SHALL DOUBT THE ADVISABILITY OF GRANTING AN INCREASED RATING FOR THE WELD, THE MATTER SHALL BE REFERRED TO THE BOILER CODE COMMITTEE FOR ITS DECISION.

PAR. P-268. REVISED:

P-268. *Threaded Openings.* All pipe threads shall conform to the American Pipe Thread Standard, and all connections 1-in. pipe size or over shall have not less than the number of threads given in Table P-10. For smaller pipe connections there shall be at least four threads in the opening.

If the thickness of the material in the boiler is not sufficient to give such number of threads, the opening shall be reinforced by a pressed-steel, cast-steel, or bronze composition flange, or plate, so as to provide the required number of threads.

When the maximum allowable working pressure exceeds 100 lb. per sq. in., outlet connections over 3 in. pipe size shall not have screwed joints, BUT flanged fittings shall be used, riveted directly to the shell or head, or a fitting with a raised flat face on the boiler side may be connected directly to the boiler or head of the boiler by means of studs.

If studs are used they must be not less than $^3/_4$ in. in diameter and must have not less than ten threads per inch. The thickness of the boiler plate must be not less than the diameter of the studs. The allowable tensile stress on these studs must not exceed the stresses indicated by the bolted connections given in Table A-6.

PAR. S-252. REVISED:

S-252. *Chemical Composition.* The steel shall conform to the following requirements as to chemical composition:

		Class 1	Class 2
Carbon, maximum, per cent		0.35	0.50 [0.45]
Manganese, per cent			0.40–0.70 [0.30–0.65]
Phosphorus, maximum, per cent	Acid		0.05 [0.04]
	Basic		0.035
Sulphur, maximum, per cent			0.05 [0.04]

PAR. S-257. REVISED:

S-257. *Bend Tests.* The test specimen shall [with] stand being bent cold through 180 deg., [around a pin 1 in. in diameter] without cracking on the outside of the bent portion, AS FOLLOWS:

FOR CLASS 1 MATERIAL—AROUND A PIN 1 IN. IN DIAMETER;
FOR CLASS 2 MATERIAL—AROUND A PIN $1^1/_2$ IN. IN DIAMETER.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The

interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 585 (Reopened), 602 (Reopened), 607, 609–612 as formulated at the meeting on October 26, 1928, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 585 (Reopened)

Inquiry: Request is made for revision of the requirement in Par. U-20 of the Code which limits the maximum allowable unit working stress in seamless shells to 9000 lb. per sq. in. It is pointed out that for the drawing of seamless steel vessels, 55,000 lb. per sq. in. material is commonly and very successfully used, so that an allowable unit working stress of 11,000 lb. per sq. in. should be allowed.

Reply: This value of 9000 lb. for the maximum allowable unit working stress came from the table in the Power Boiler Code for piping and is conservative in view of the fact that the piping is provided for use up to a maximum temperature of 750 deg. fahr. It is the opinion of the Committee that for temperatures up to 600 deg., one-fifth of the minimum of the specified range of the ultimate strength can be used. This matter is under consideration for revision.

CASE NO. 602 (Reopened)

Inquiry: Is it permissible to use a constant of 135 in the formula given in Par. H-21 of the Code for ordinary staybolts welded into plates forming the water leg of a boiler? It is pointed out that these staybolts do not exceed 6 ft. in length.

Reply: It was the intent to limit the use of 135 for the constant C to stays over 120 diameters in length, and it is proposed to revise Par. H-21 to include this limitation.

Pending a revision of the Code that will clarify this feature and will limit the use of 135 for the constant C to stays over 120 diameters in length, the constant 135 may be used for steam-heating boilers and hot-water boilers for pressures not to exceed 30 lb. per sq. in. for welded-in stays and for staybolts which are screwed through the plates with their ends riveted over. For hot-water heating boilers carrying pressures over 30 lb. per sq. in., the constants for welded-in stays should correspond to those given in the Code for the ordinary screwed staybolts.

CASE NO. 607

Inquiry: Is it permissible, under the Code for Unfired Pressure Vessels, to construct a spherical shell with lap joints, or is it required that butt strap joints be used?

Reply: While there is nothing in the present Code applying to the construction of spherical vessels, it is the opinion of the Committee that lap joints may be safely used in the construction thereof if the plate thickness does not exceed $^1/_2$ in. A revision has been proposed to this effect which will be published for incorporation in the Code.

CASE NO. 609

(In the hands of the Committee)

CASE NO. 610

(In the hands of the Committee)

CASE NO. 611

Inquiry: Is it necessary, under the Rules of the Code for Unfired Pressure Vessels, that pipe material obtained under the Specifications of Section II of the Code shall be marked as called for in Par. U-122? Pipe material is apparently permitted by Par. P-9 for power boilers, even though there is no requirement in the specifications for marking thereon.

Reply: Markings are not required by any of the pipe-material specifications in Section II of the Code, in the manner prescribed for steel boiler plate, and it is the opinion of the Committee that such marking is not required for pipe material when used for pressure parts of boilers or unfired pressure vessels.

CASE NO. 612

(In the hands of the Committee)

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Better Riveted Joints

TO THE EDITOR:

Regarding Dean Arthur M. Greene's communication on "Better Riveted Joints," on page 804 of MECHANICAL ENGINEERING for October, the writer's own practical observations as an inspector of mechanical work for the New York City Board of Water Supply may be of interest.

Referring especially to the fabrication of riveted steel pipe ranging from 9 ft. to 11 ft. 3 in. in diameter, using $^7/_{16}$ in. to $^9/_{16}$-in. open-hearth flange-steel plates and 1-in. diameter rivets, the writer's conclusion is that the margin between ideal and ordinary shop practice is entirely too large.

1 The reaming of holes to $1^1/_{16}$ in. for 1-in. rivets is unnecessary, and allows too much "cocking" of rivets in the holes, giving rise to the formation of eccentric heads. Under this condition, also, the tendency is for the "bull" not to exert its driving pressure squarely with the axes of the rivets.

2 In many plants there is a slackness in properly removing burrs from the edges of punched or drilled rivet holes.

3 After pipes have been "laid up" and "regulated" (assembled for riveting), the holes are reamed. Carelessness is apparent here, in that enough attention is not paid to having the reamer work along a line radial to the pipe axis. This also tends to produce cocked rivets and eccentric heads.

4 It is not possible, when "laying up," to bring the joint surfaces to such close contact that reamer cuttings will not work in between these surfaces. It is probable that these chips are partly flattened and partly impressed into the joint surfaces by the pressure of the riveting "bull," when the rivets are driven. It is, of course, altogether desirable that the contact surfaces of the plates in a riveted joint be entirely clean and free from foreign matter. This is not customary, however, so far as can be ascertained, even in boiler-fabricating plants.

Common practice may be "good enough," but it is some distance from being as good as it might be.

If reaming to $1^1/_{16}$ in. is necessary for coincidence of holes, then the rivets should be over 1 in. in diameter or the holes should be punched or drilled smaller and then reamed to somewhat over 1 in.

These are the chief points which have impressed the writer as being "sloppy" work, and he is herewith transmitting his observations as of possible interest to others.

WALTER G. THORNTON.[1]

New York, N. Y.

The Boiler Unit of Evaporation[2]

TO THE EDITOR:

In MECHANICAL ENGINEERING for September, 1928, beginning on page 689, Prof. W. A. Shoudy and W. H. Jacobi presented "A Suggestion for Rating Steam Boilers."

These authors make several constructive suggestions of considerable interest. There has been quite a lot of discussion among engineers for several years about the B.t.u., the boiler unit of evaporation, the therm, etc. Much of this discussion has been jocular or only semi-serious. It was suggested that the American B.t.u. be made equal to 1000 ft-lb. of work in order to be bigger than the British B.t.u. Similar suggestions have been equally humorous.

The writer suggested also in a half-humorous way last spring through a letter in *Power* (June 26, 1928, page 1154) that the boiler unit of evaporation be termed the "Bute." This term is made up of some of the first letters of the words in the phrase "boiler unit of evaporation." The pronunciation should be one syllable. The plural would be "Butes," also pronounced as one syllable.

It was the writer's intention that the Bute should stand for 1,000,000 B.t.u. This it seems to him would have many advantages. It would give engineers the large unit which they need, it would be different from the English therm, and would replace the awkward or at least long term of "one million B.t.u." which they have to use so frequently.

Since the term "boiler horsepower," which we are trying to eliminate from our power-plant vocabulary, is equivalent to 33,479 B.t.u., the "bute" would be equal to about 30 boiler horsepower. This would be a convenient figure to remember for those who feel they should have a mental relation between old and new units.

The average large steam generator with superheater and feedwater heater requires 1000 to possibly 1100 B.t.u. per pound of steam evaporated. If 10,000 lb. of steam were delivered per hour, then about ten Butes would be required to make that much steam. For 500,000 lb. of steam per hour 500 Butes would be required. This represents the limit of present manufacturing, but even if steam generators capable of delivering 1,000,000 lb. of steam per hour should be developed, 1000 Butes is not an unwieldy term to use.

The term "per million B.t.u." has been used for stating the duty of pumps so long that it seems much easier to say "duty per Bute" than "duty per thousand kilotherms."

The term Bute (if it stands for 1,000,000 B.t.u.) is easily used throughout our technical literature. In the Philip Carey Company's Bulletin 101-A at the bottom of page 3 we find "at a cost of $0.30 'per million B.t.u.,' which is a conservative figure, the annual loss from one (square) foot of such (12 diam. bare pipe, 750 deg.–80 deg. fahr.) pipe is $36.27." It would be much simpler to "30 cents per Bute."

In *Power*, July 24, 1928, page 139, W. D. Canan in his article, "What It Costs to Generate Industrial Power," uses 1,000,000 B.t.u. in his curves. The use of the Bute would be less awkward. In the same journal of July 26, 1927, page 140, in the article, "What Capital Expenditure Is Justified by Thermal Savings?" the comparison of fuel cost in pounds per million B.t.u. is used. It would be simpler to use pounds per Bute.

The above are a few samples noted recently. Their number could be increased indefinitely. The writer suggests the term Bute as it is simple, easy to remember, and easily associated with B.t.u. But whether or not it, or the suggested "Rumford," or any other term is finally adopted, it is really necessary, it seems to him, that the term should stand for 1,000,000 B.t.u.

WM. J. DANA.[3]

Raleigh, N. C.

Stresses and Reactions in Expansion Pipe Bends

TO THE EDITOR:

In reading over Mr. Bato's letter printed in the December issue of MECHANICAL ENGINEERING, p. 964, I gathered the impression that *after* he had received Professor Hovgaard's communication he applied my formula (Equation [13] of my paper on pipe bends) to Professor Hovgaard's tests and obtained a discrepancy of 50 per cent, thus indicating that my formula was 50 per cent in error. However, I have recently received a letter from Mr. Bato informing me that this was not the case and that he obtained this discrepancy *before* he received the letter from Professor Hovgaard. Therefore, the discrepancy of 50 per cent mentioned by Mr. Bato was not due to inaccuracy of my Formula [13] nor to an error by Mr. Bato in applying the formula, as I had supposed, but rather to a mistake in the wording of Professor Hovgaard's paper. I regret that I misunderstood the meaning of Mr. Bato's letter, but am gratified to know that we are in accord.

A. M. WAHL.[4]

East Pittsburgh, Pa.

Correlation of Steam-Research Data

(*Continued from page 129*)

or about 298.1 deg. fahr. This is the temperature at which "steam at zero pressure" has the same enthalpy as saturated steam at its point of maximum enthalpy. To an experimentalist this figure is interesting, because it means that if we knew well the specific heat of steam at low pressures up to 300 deg. fahr. we should be in a position to compute saturation enthalpies throughout the range accessible by Joule-Thomson methods. The accurate measurement of C_{p0} at low pressures in glass or quartz apparatus over a temperature range extending only to 300 deg. fahr. should be fairly easy, if any calorimetric work can be called easy, and is an experimental job that should be undertaken at the earliest possible opportunity. Fortunately the μ's involved in the subsequent computation of saturation enthalpies throughout the most important range thereof, are at pressures and temperatures where the Harvard Joule-Thomson work was at its best.

Additional Joule-Thomson measurements at low pressures and at temperatures below about 150 deg. cent. or about 300 deg. fahr. are also much to be desired because of the help which such measurements would give in establishing a formulation of μ even more suitable than any yet obtained for dependable extrapolation.

[1] Engineering Bureau, Board of Water Supply, City of New York.

[2] This matter was discussed by the A.S.M.E. Main Committee on Power Test Codes at its December 3, 1928, meeting and was referred to Individual Committee No. 2 on Definitions and Values, R. J. S. Piggott, Chairman, for further consideration and report.

[3] Professor of Experimental Engineering, N. C. State College. Mem. A.S.M.E.

[4] Mechanics Section, Research Department, Westinghouse Electric & Manufacturing Co. Mem. A.S.M.E.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK,
Aeronautic Division
A. L. KIMBALL, JR.,
Applied Mechanics Division
H. W. BROOKS,
Fuels Division
R. L. DAUGHERTY,
Hydraulic Division
WM. W. MACON,
Iron and Steel Division
JAMES A. HALL,
Machine-Shop Practice Division
CHARLES W. BEESE,
Management Division
G. E. HAGEMANN,
Materials Handling Division
J. L. WALSH,
National Defense Division
L. H. MORRISON,
Oil and Gas Power Division
W. R. ECKERT,
Petroleum Division
F. M. GIBSON and W. M. KEENAN,
Power Division
WINFIELD S. HUSON,
Printing Industries Division
MARION B. RICHARDSON,
Railroad Division
JAMES W. COX, JR.,
Textile Division
WM. BRAID WHITE,
Wood Industries Division

Applied Mechanics

Gas Discharge Through Orifices

AM-1 Two vessels of equal volume, A and B, are filled with gas of known chemical composition. The pressures in A and B are equal, and the common pressure is greater than standard atmospheric pressure. The density of the gas in A is different from that in B. Each vessel is discharging gas through an orifice into standard atmosphere. The orifices are so constructed that their areas and coefficients of discharge are equal. The areas of the orifices are such that the pressure in the main vessel will not be appreciably affected by the gas discharged in a unit time increment. What is the relation of the volume discharged from A to the volume discharged from B expressed as the ratio of the density of the gas in A to the density of the gas in B?

The volumes discharged per second are inversely proportional to the square roots of the densities:

$$\frac{\text{Volume } A}{\text{Volume } B} = \frac{\sqrt{\text{Density } B}}{\sqrt{\text{Density } A}} \quad \ldots\ldots\ldots\ldots [1]$$

The weights discharged, however, are directly proportional to the square roots of the densities:

$$\frac{\text{Weight per sec. } A}{\text{Weight per sec. } B} = \frac{\sqrt{\text{Density } A}}{\sqrt{\text{Density } B}} \quad \ldots\ldots\ldots\ldots [2]$$

These follow from the equations derived in thermodynamics on the theory of the flow of fluids; for example: Goodenough's "Thermodynamics," pp. 146–148.

If the two gases have different numbers of atoms per molecule (as, N_2 against CH_4), then, in addition to the above relations, there is a minor correction for the different adiabatic coefficients k. The higher the number of atoms per molecule, the lower the weight and volume delivered; thus,

No. of atoms	k	Relative discharge[1]
1	1.667	1.061
2	1.4	1.000
3	1.3±	0.974
4+	1.2±	0.947

[1] Relative to diatomic gases, which are the most common (as air, O_2, H_2, N_2, CO).

Relation [1] may be derived in an elementary way by saying that the pressure is equal to the product of an equivalent height of gas and the gas density (the hydraulic formula $p = wh$); and the velocity of discharge is proportional to the square root of the height (Vel. $= \sqrt{2gh}$) hence, for a given pressure, the velocity is inversely proportional to density. Then *Velocity* × *Area* × *Discharge Coefficient* gives volume discharged; hence volume is inversely proportional to density. (John G. Fairfield, Assistant Professor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y.)

Fuels

Catalyzers for Use With Coal

F-3 With what success has a mineral-salts catalyzer been used with No. 1 buckwheat coal? What has been the effect on the CO_2, and has there been any material effect on the boiler tubes?

The writer is not sure what is meant in this question by a "mineral-salts catalyzer." It may refer to one of the numerous preparations appearing on the market from time to time and which are said to increase the amount of heat that can be obtained from buckwheat coal. It is the writer's understanding that these preparations are as a rule nothing more than common salt mixed with finely ground coal or ash, which, when sprinkled on the coal in the form of a water solution, produces a luminous flame when the coal is burned. So far as the writer knows, these preparations have no effect at all on the burning characteristics of the coal or the amount of heat liberated. (H. R. Towse, Manager, Data Department, Combustion Engineering Corporation, New York City.)

Sampling From Unit Coal Pulverizers

F-4 What method is recommended for taking samples from ducts leading from unit coal pulverizers to the burners?

(*a*) The mixture of pulverized coal and air moving through a circular duct is never uniform as to quantity and fineness of coal. One part of the section of the duct usually contains more coal than other parts. Also the fineness in one part of the cross-section is different than in other parts of the cross-section. In addition to this variation the mixture in any one section may vary from moment to moment. It is therefore very difficult to obtain an absolutely representative sample of the coal.

The most commonly used method for sampling coal for the determination of fineness is to collect the sample with an impact

tube made somewhat similar to a pitot tube used for measuring velocity of fluids. The impact or sampling tube is moved into different positions on the inside of the duct carrying the mixture of coal and air. The cross-section of the duct is divided into rings of equal area in a manner similar to that employed in pitot-tube measurements. The intake end of the sampling tube is held in each ring for a definite length of time, usually about one minute. The duct is traversed as many times as necessary to collect the desired sample. Fig. 1 illustrates the position of the intake of the sampling tube in a circular duct.

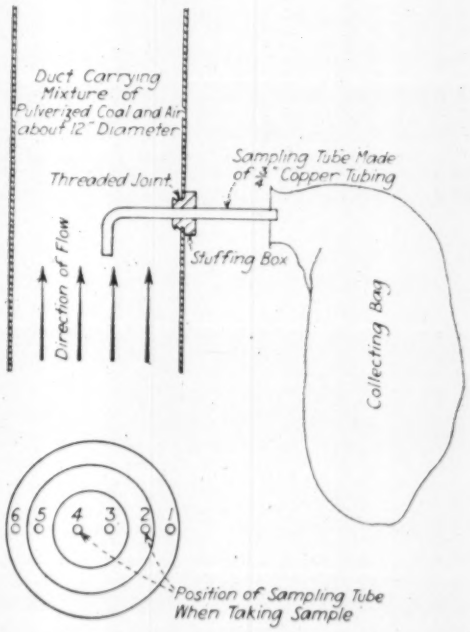


FIG. 1 METHOD OF SAMPLING PULVERIZED COAL SUSPENDED IN AIR

The coal is collected in a bag attached to the outlet end of the sampling tube. This bag may be either a vacuum-cleaner bag or a pillow case of fine weave.

The velocity of the mixture of coal and air passing through the sampling tube should be approximately the same as the velocity of the mixture through the duct. It is impossible to make this velocity exactly the same because the velocity in the duct varies, being lower near the walls and higher in the center. The velocity through the sampling tube also varies during the time the sample is collected. At the beginning of the sampling period, when the bag is clean, more air flows out of the bag and the velocity of mixture going through the sampling tube is high. At the end of the sampling period when the walls of the collecting bag have been covered to some extent with coal dust the flow of air out of the bag is reduced and the velocity through the sampling tube is decreased. The variation of the velocity through the sampling tube may be reduced if the vacuum-cleaner bag is of extra large size so that it presents a greater surface for filtering out the air.

It is preferable to collect the sample in a vertical pipe, the mixture either flowing up or down. It is also advisable that the sampling be done as far from the mill blower as possible in order to get away from the separation effect of the blower. (Henry Kreisinger, Research Engineer, Combustion Engineering Corp., New York, N. Y.)

(*b*) An interesting discussion of this subject appears in the December 18, 1928, issue of *Power*, page 1003. In a paper on the subject "Accurate Sampling from Unit Pulverizers," P. A. Willis, Associate Professor of Mechanical Engineering, School of Mines and Metallurgy, University of Illinois, describes a system similar in some respects to that described by Mr. Kreisinger. Professor Willis' sampler employs a vacuum-cleaner attachment to withdraw the sample from the duct, and his paper shows the effect of speed on the sample, and the best manner of applying the apparatus to the duct. (EDITOR.)

Wood Industries

CONVEYORS IN PAPER MILLS

WI-1 What types of conveyors are used in paper mills, and what is the general practice in moving materials and finished product around the plant?

On account of the large number of different kinds of raw materials used and the different forms of the finished product, almost every kind of ordinary conveyor is used in the paper industry.

Pulpwood. A large portion of the pulpwood is handled with button cable conveyors in V-shaped troughs. Some plain chain conveyors are used, and the pulpwood stacker is a special conveyor developed within the industry. The crane and wood grapple are used to some extent for both 4-ft. pulpwood and long logs. In the chemical processes where the wood is cut into small chips, these chips are conveyed by means of belt conveyors, bucket elevators, or by air, according to the layout of the plant and the handling conditions encountered.

Old Paper Stock and Rags. Most of this material comes in bales and is handled by hand trucks of various types, electric trucks, overhead cranes equipped with a grapple, and various types of belt and apron conveyors.

Lime, Limestone, Sulphur, and Clay. These materials are handled by various equipment used to convey granular commodities. The belt conveyor, the bucket elevator, industrial car, and the air-suction lift are all means employed to move the above materials. There are other special adaptations of handling equipment that are applied to these materials.

Coal. In the large modern mill considerable coal is used, and usually the coal-storage equipment is so laid out that the modern methods of coal handling are employed. The drag scraper is favored in many new plants. Some mills use the belt conveyor, others the flight conveyor, and some use the bucket-elevator type. Again this depends upon the layout.

Pulp. Water is still the important method of conveying pulp in slush form in the paper mill between departments. Pumping this stock, which ranges between one-half of 1 per cent and 6 per cent consistency, is the most economical and effective method of conveying where the pulp is immediately used. Whenever pulp is dehydrated over wet machines or by other means, it is moved by means of belt conveyors, hand trucks, electric trucks, etc. Some of the baled pulp is handled by means of overhead cranes or monorail systems.

The Finished Product. Paper is shipped in the form of rolls, as bundles, or in cases. The roll shipments of paper are largely handled by special types of roll trucks similar to the barrel hand truck. Where the roll shipments are large, the special roll-handling electric truck is used. The bundles of paper are handled largely by regular 4-wheel trucks. Some mills use the skid and electric lift truck to handle this material to a certain extent. Cases and flat paper also are handled by the regular 2-wheel barrel or similar truck, or by means of skids and the electric lift truck. The use of the skid and the lift truck in paper shipments is being more widely adopted, and this was discussed by F. J. Shepard, Jr., in his paper entitled "Skid-Platform Shipment of Commodities," at the 1928 Annual Meeting of the A.S.M.E. (Geo. D. Bearce, Engineer, Manufacturing Department, International Paper Co., New York, N. Y.)

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

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BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or .... printed in its publications (B2, Par. 3).

What Price Glory?

LEGISLATION permitting the War Department to place "educational" orders for the manufacture of war material is now in process of formulation. Engineers, who have the task of putting new products into production and who appreciate the difficulties in the way of producing non-commercial products quickly and economically in large quantities, welcome this important addition to the legislative provisions for industrial mobilization in event of a major emergency.

The National Defense Act of 1920 recognized the fact that military supplies are essentially non-commercial and set up an Assistant Secretary of War to organize industry for the provision of these supplies in event of emergency. Since the passage of the Act, excellent progress has been made. Requirements have been calculated, the country has been divided into procurement districts, the requirements have been allocated to these districts, and manufacturers have started emergency production plans. Legislation is needed so that these plans can be tried out. "Educational" orders must be provided by the War Department if our manufacturers are to perfect their plans and teach their men the requirements of the finished product. This is a matter of basic importance with articles of a non-commercial nature such as ordnance, which makes up the largest and most expensive part of the requirements of the War Department.

The deterioration of ammunition stored since the last war affords an immediate opportunity for a trial of the "educational" order idea. Certainly our manufacturers have greater need for training in the making of arms and ammunition than our reserves in the handling of these same arms and ammunition. Bryan once said that our citizens would spring to arms over night to defend the country from attack. But if there are no arms and ammunition, what price glory?

The Properties of Steam

THERE are published in this issue the papers of the Steam Table Session of the A.S.M.E. Annual Meeting which took place Wednesday, December 5, 1928. The work during the year has been most fruitful in England, Germany, and Czechoslovakia, as well as in this country. The work in England by Callendar was published in the Proceedings of the Royal Society, but is given in somewhat more detail in three lectures by him at the Royal Institution, Albemarle St., London, and published in *Engineering* (London) of November 9, 16, and 30, 1928. The long-expected high-pressure and high-temperature specific heats of Knoblauch were published in the *Zeitschrift des Vereines deutscher Ingenieure* of December 1, 1928, and will be found in abstract in the Survey of Engineering Progress, page 147 of this issue.

The work of Zvoniček and Havliček of Czechoslovakia was presented in paper No. J2 at the Fuel Section of the World Power Conference, London, September, 1928, but Professor Havliček has written for this issue an article covering points not published in the Conference paper and discussing his results in comparison with the English and American work. This article appears on page 127.

Practically the entire field has now been covered by experiments and the comparing and checking are quite good, and it may be confidently asserted that the departures from accuracy will be of the order of one part in four or five thousand. American and European scientists await with interest the publication by Callendar of his actual experimental points so that the English work may be used as a countercheck on the measurements already published. Tentative proposals looking toward international agreement on basic values for the properties of steam are now well under way, and it is hoped by every one interested in this work that full publication of all experimental facts may be secured in the near future.

A Dictionary of American Biography

THE contribution of the engineer and inventor to the tradition of America receives recognition in the first volume (recently issued by Scribner's) of the "Dictionary of American Biography." Under the guidance of the American Council of Learned Societies, the list of Americans deemed worthy of a place in the Dictionary is being built up of those whose actual achievements in contributing to the nation's life and history have earned them the right to inclusion.

Judged on such standards alone, it has been inevitable that engineers, in increasing numbers, have found their places alongside statesmen, clergymen, teachers, physicians, writers, musicians, and men of science; while others, whose fame has had its foundations in hollow honors or public offices pompously administered, have been quietly disregarded.

The biographical sketches in the Dictionary are, for the most part, brief. Few run over a thousand or fifteen hundred words. But, even with this brevity, an attempt is made to record the human qualities of the individual as well as his specific attainments. A picture of the whole man, rather than just of his work, is the aim. Accuracy of fact has been doubly assured by a discriminating choice of biographer in the first place, and then by the careful checking of each sketch by experts in the Congressional Library at Washington under the direction of the Dictionary's editor-in-chief. To each sketch is appended a list of sources from which the material has been obtained. This last fact alone gives the work a value beyond anything ever before achieved in this country.

Among the more than two-score names in the first volume which

are of special interest in the world of engineering and mechanical industry are: Isaac Adams, inventor of printing machinery; James P. Allaire, master mechanic and engine builder; Nathan Peabody Ames, metal worker and manufacturer; Albert Arents, Philip Argall, and Edward Balbach, metallurgists; John F. Allen, one of the charter members of the A.S.M.E., and inventor with Chas. T. Porter of the Allen, later the Porter-Allen, engine; Edward Phelps Allis, founder of the Allis Company, engine and machinery manufacturers of Milwaukee; Horatio Allen and Matthias Wm. Baldwin, locomotive builders; George Herman Babcock, co-inventor with Stephen Wilcox of the Babcock and Wilcox steam boiler; and Isaac Babbitt, known for the bearing metal associated with his name.

Dr. W. F. Durand, Past-President of the Society, is one of the contributors to the first volume.

The "Question Mark"

TO THE general public the flight of the *Question Mark* is merely a spectacular performance. To an engineer it represents an unusually difficult job of testing magnificently performed. It may be considered to have already answered a number of questions besides the major one, for the sake of which the test was undertaken. In the first place, it has shown that what are generally referred to as plumbing troubles are due not to any inherent weakness of materials and apparatus, but apparently to lack of care or skill in fitting out planes. An oil- or gas-pipe leak would have speedily cut down the flying time of 150 hours, but none occurred, which shows that if proper care is taken, such leaks never need occur—and, incidentally, they never did interfere with any of Col. Lindbergh's flights.

The flight of the *Question Mark* gives a substantial answer to the question as to the flying life of our present motors. If a motor can fly 150 hours steadily, without stopping or overhaul, it is fair to assume that it will do at least twice as well if not abused, which means that, with proper overhauls and at least brief periods of rest, the motors are good for a sustained flight around the world, or a service of, say, 300 hours, equivalent to 30,000 to 40,000 miles. It will be extremely interesting to see the report of the Army as to the state of the motors when opened up, and all indications are that they can be put into shape for further work with only a moderate expenditure. If this is so, then it is reasonable to assume that the motor cost per mile of flight for a single-motored plane will not be much over 20 cents, which, considering the low cost of fuel per mile, is not prohibitive for commercial flying where time is of value.

The Army has proved the complete feasibility of refueling in the air, and its commercial and especially its military value may now be considered. To the man in the street, refueling in the air seems to reflect the extreme hurry of the age, for the plane could come down on a landing field and refuel at leisure. What the man in the street does not know, however, is that there may easily be situations where the plane cannot come down to refuel. Take for example the case of a flying boat in very rough weather at sea. Even if it could land alongside a mother ship, the refueling operation would be very hazardous and difficult; also, not having the proper landing gear, a flying boat cannot land on the deck of a service vessel. The same situation might arise when a flying boat had to cross a stretch of dry land, or when, as was the case in Nicaragua, planes had to operate over jungle territory at considerable distances from such landing fields as were available.

The day is coming when every large ship will carry at least one plane, and it would not be at all surprising if ships would then carry on quite a profitable trade in gasoline for the transatlantic air passenger lines. The flight of the *Question Mark* proves one important thing if nothing else, and that is that developments in aeronautics are possible today on a scale undreamt of by the average man. The U. S. Army is therefore to be greatly congratulated on having had the courage to undertake such a test and the ability to carry it through so splendidly, and especially on its good fortune to number among its personnel five men with such skill, courage, and endurance as these pathfinders have shown themselves to possess. Incidentally, the flight of the *Question Mark* may serve as a notice to all whom it may concern that although Uncle Sam does not have today a numerically large fleet of argosies of the air, he nevertheless now knows how to create an air defense without—as was the case in 1917—having to copy foreign designs.

Railroad Valuation

THERE is now before the United States Supreme Court a case, the like of which in national importance, it may turn out, has not been before that body since the Dred Scott decision. It is the case of the St. Louis & O'Fallon Railroad. On the face of it is merely a matter as to whether the railroad, a short line owned by the Busch interests of St. Louis, should pay to the Government the share of its profits specified by the Esch-Cummins Transportation Act. The amount of income and the right of the Government to a share of the profits, if any, are not denied, but the railroad claims that it should be valued for purposes of the Act by the reproduction costs of today, while the contention of the Government is that the valuation of 1914 must be accepted.

If the contention of the Government is upheld, the result will be simply that things will continue as they are today. If, however, the railroads win (and the fight of the little road is being backed by a majority of the Class A railroads), some very revolutionary changes will take place. To begin with, the valuation of the Class A roads under the Interstate Commerce Commission's interpretation is $23,000,000,000, but the valuation when using the "cost of reproduction" formula is in excess of the sum of $32,000,000,000. The difference is not a theoretical one by any means. The passenger and freight rates which the I. C. C. under the law must permit the roads to charge are such as to give them a reasonable return on the capital invested, *alias* their valuation, which means that should the roads win before the Supreme Court, a boost of rates to the tune of, say, 45 per cent will be in order. It is obvious, however, that such a rise is more than the traffic will bear, which means that the roads will be in a position to—indeed, compelled to—charge less than the rates permitted by the I. C. C. How much value the regulatory power of the latter will have under these conditions remains to be seen, and it will be affected to a large extent by such additional legislation as may be caused by such a disturbing situation. The fact remains, however, that our American industries have grown up under the existing system of rates, and any profound change in this system, particularly one coming with the suddenness of a thunderclap out of a clear sky, is apt to prove highly upsetting.

Whether the railroads themselves will profit by their victory—assuming that the Supreme Court will decide in their favor—is still a question. Apart from the fact that such troubles as the roads are having today are primarily due to causes other than excessively low rates for transportation, there are other questions which the new process of valuation is apt to raise, and one of these is the possibility that it will immobilize completely the existing corporation structure of American railroads and prevent those very consolidations for which the Transportation Act provides, and which is considered of such importance by the roads themselves. This may happen because of the matter of income tax involved. If a road which was worth, according to its own contention, $100,000,000 in 1913, is sold to another company as being

worth $145,000,000 today, the Treasury Department will step in and ask for the taxes on the difference, as has been so dramatically illustrated in the recent case of the former Ford Motor Company stockholders. Where will the companies get the cash to pay the income tax? and will they be able to afford to put through the pending mergers with this complicating condition?

The Stock Ticker

BECAUSE of the fact that the organization of our security market is completely dominated by the New York Stock Exchange and because of a sudden unprecedented expansion of trading in stocks, the ticker has suddenly acquired unusual importance and stands as a challenge to American ingenuity.

The first successful ticker was devised by Thomas A. Edison, and substantially the same type has remained in service up to the present. However, the four- and five-million-share days of the past 18 months have proved its inadequacy. Several solutions have been suggested, the simplest—apparently—being to install duplicate equipment. But this is easier said than done, as two tickers would require an immense amount of additional wiring which could not be brought into some of the downtown office buildings at all for structural reasons.

The suggestion that the present ticker be replaced by telephone transmission of quotations is also impracticable because the present ticker with its carrying capacity of about 10 signals per second works faster than would telephoning. The only way, therefore, is to speed up the ticker itself. The following figures may prove of interest in this connection. There were 14,700 stock transactions on a recent day with a total turnover of close to 5,000,000 shares, and this may be taken as a representative average. As each transaction requires from 10 to 11 signals on the ticker tape (e.g., 1200 XYZ 147⅝, which means 1200 shares of XYZ Company have been sold at $147.625 per share), the day's business can be handled by, say, 160,000 signals. If these were uniformly spread over the five hours of trading, this would mean 32,000 signals per hour, or roughly 9 signals per second, which is within the capacity of the present ticker. Actually, however, even in such big markets as we have been having of late, trading is not uniform throughout the day. In the morning there are quantities of orders which have been wired in from outside points during the night, and these as well as other orders are specified for execution at the opening of the market, which means that the ticker begins to lag behind the market right from the start. The last hour or so of trading is also apt to be heavier than any other period, and the result is that just when it is most important to know what is going on in the market, the ticker may be from forty minutes to an hour or more behind the actual facts, which means that it becomes a danger rather than a help to any trader.

It is stated that a Chicago firm has developed a new ticker which has been already approved for use by the New York Stock Exchange, and which will transmit 15 signals per second—sufficient, it is believed, to handle a market with a turnover as high as 7,000,000 shares. With the country growing as it is, and with the artificial stimulation of stock trading by the split-up of shares which makes ten shares grow when one bloomed before, a market of 7,000,000 shares is entirely too imminent for the comfort of the Stock Exchange authorities. Here, therefore, is a problem for American engineers which has only been half-solved—a challenge to their ingenuity that promises a reasonable financial return to the lucky one who will find the right answer.

Pitfalls of Research

BECAUSE of the great popularity today of what passes for "research," a few words of caution may not be out of place. Research is not a universal panacea for falling profits. In some industries, as, for example, the textile, the greatest promise of rehabilitation probably lies in the direction of research, but this is because the textile industry has been notoriously backward, and in order to survive at all, must have imparted to it that "industrial acceleration" which is impossible without research. In the case of more progressive industries, however, research may prove to be enormously valuable (as witnessed, e.g., by the developments in new cutting materials within the last twelvemonth), but should not be expected to be so in every case. If, therefore, a research man is hired and the earnings do not jump 100 per cent in the next six months, he need not be blamed every time.

A distinction which should be clearly borne in mind is that between fundamental research as against what might be called the bread-and-butter type. Only large and wealthy companies can afford the former kind of research, notwithstanding the fact that if properly conducted and carried on on a large-enough scale, fundamental research will pay for itself. It is not the kind, however, that will pay promptly, and years may pass before any return is obtained. The atomic-hydrogen system of welding developed by Dr. Langmuir at the General Electric Company's works is an outcome of certain special research work on the cooling of tungsten filaments in gas-filled lamps which started more than 15 years ago.

The most important thing about research, however, is that, like all engineering work, it cannot be done without proper tools. To hire a recent graduate of a technical school and give him the munificent sum of $300 to spend for equipment is not the proper way to start a research department. True, Michael Faraday discovered the laws of electromagnetic action with equipment that cost little more than that, but in the first place, some research workers are not Faradays, and next, times have changed and modern research work, to be successful, requires proper facilities. In fact, as time goes on, tooling up of the laboratory becomes the first condition of success, and measurement and recorded observation take the place of the theorizing which had to be resorted to in the past for lack of precise observation. The following instance may illustrate this. In connection with the phenomenon of shimmy in automobile wheels equipped with balloon tires, the research department of an automobile company observed a running car under the Stroborama, a modified type of stroboscope. Not only was new light thrown on the shimmy, but to every one's surprise it was found that no two of the four wheels ran alike, which started a new and promising train of research. How could a man without a Stroborama or similar instrument discover this unsuspected fact?

What should be clearly understood is that, just as the sales department of the Jones-Smith Mfg. Co. competes for business with the sales departments of every other company in the same line of business, so does the research department of that concern compete with similar departments in the other companies. No one would think of hiring a sales manager and giving him $10 worth of stationery and then expect him to obtain results, and yet many a research department has been started with inadequate equipment and a most niggardly appropriation.

There is one element in connection with the conduct of any research department that is becoming of growing—one might almost say, annoyingly growing—importance, and that is the matter of cooperation with outside research projects. A large company with a well-organized research department is naturally interested in everything even remotely connected with its line of activities, and ought to be willing—within reason—to cooperate with outside agencies working along the same or similar lines; but the time has about come to ask, "What is cooperation within reason?" It is not at all difficult to get together a dozen men and decide to investigate the cause of some such matter as the

corrosion of iron, fatigue of metals, atomic structure, etc. When, however, the idea of the gathering is not to undertake the work but to get the bigger companies to do it through their research departments, and merely communicate the results to the new research body, a question arises as to what extent the work of men can be spared from their regular program and deflected to the outside and often rather indefinite activity. Every large research laboratory can cite one or more instances where it has been asked to do work that would cost it many thousands of dollars, with only the haziest promise that after it had done the work there would be provided the necessary facilities for drawing from it the necessary conclusions; so that the impression prevails at times that not only will tasks of this kind be burdensome but that they will be profitless in the higher sense of the word as well. It would therefore be highly desirable to work out some plan whereby general research problems could be sorted out and the laboratories of commercial companies relieved of the onus of being asked to do that which would not be of the slightest use even if it were done.

A Materials Employment Agency

IT WOULD seem odd to see an advertisement in a paper reading something like this: "Wanted, job for a metalloid known as sulphur; yellow, but thoroughly respectable and willing to work." And yet this is what is regularly happening nowadays, though not expressed quite as specifically as above. Materials hitherto useless or little known are being put to work, and at the same time the prayers of the engineer and chemist for materials that they want are being answered—and at times from very unexpected sources.

There is a rather rare element called gallium which has been a laboratory curiosity for half a century. A couple of years ago it was found to be highly suitable for use in thermometers for measuring temperatures far above those at which mercury vaporizes. Still more interesting is the case of sodium, which has been known for a long time and can be produced in unlimited quantities, but for which until recently no use has developed that would require more than a few pounds. Then a Cleveland chemist discovered that while an ordinary silicon-aluminum alloy is rather weak mechanically, it changes its properties when a small amount of sodium is used in the melt. There is a good reason to believe that sodium will soon be used as a deoxidizer, and possibly as a catalyst, in the manufacture of other alloys as well.

However, metals are not the only substances for which work is being found. Take cornstalks. Only a little while ago they were good for nothing better than burning in a furnace, and not very good for that. Today whole industries are being planned around the humble cornstalk, such as the manufacture of paper, furfural, etc., and the day may not be far distant when corn itself will be looked upon as a by-product.

For a long time the analytical chemist has used phenolphthalein as a sensitive reagent for determining the alkalinity of a solution. Phthalic acid, however, was a laboratory curiosity until recently. Then a method of making it in tank-car lots at a low price was discovered, and a use was immediately found for it in the making of a new condensation product based on glycerine and already used in electrical engineering. However, another important organic chemical, formaldehyde, while already extensively used, is barely finding its true fields of usefulness.

Exciting as is the hunt for new jobs for materials, the "help wanted" column of today's engineering is no less interesting. There we find a crying appeal from one group of engineers for a ferrous material that will not rust and will be cheap enough to be used in ordinary construction. Another group ask for a material that will not expand at high temperatures, or will behave then practically as invar and elinvar do at room temperature. There are plenty of jobs ready for beryllium if only it can be produced at a cost to compare, say, with that of magnesium. In this connection one might mention two other metals, chromium and aluminum, both of which would be used on an enormously greater scale if only a way could be found to extract them from their ores by cheaper methods, or if cheaper ores could be used. When the day comes that aluminum can be obtained from clays at a cost of something like 5 cents a pound (and there is but little doubt now that this will eventually happen) and chromium can be produced for about the same figure, we shall have rustless bridges and skyscrapers made with aluminum-alloy frameworks and rising 2000 ft. into the air. Engineering construction today is limited by the availability and cost of materials—and by little else.

Section M, A.A.A.S.

SECTION M (Engineering) provided an excellent program for its sessions at the Annual Meeting of the American Association for the Advancement of Science in New York, Dec. 27, 1928 to Jan. 2, 1929. In these sessions it covered two important fields which lie in the borderland between science and engineering. A symposium on the chemistry of metals held jointly with Section C (chemistry) on Friday, included several papers of interest to engineers, and mere mention of the names of the speakers and the organizations represented by them attests to their excellence.

The Saturday session was devoted to research in industry, and was interrupted at noon by adjournment for luncheon at the Fraternity Club, at which Dr. Michael I. Pupin, of Columbia University, was the principal speaker. Dr. Pupin stated that through the university professor the spirit of idealism had grown up in the university and industrial research laboratories. This had been accompanied by the cultivation of the philosophy of a definite motive of unselfishness, an unprejudiced and open-minded mental attitude, and a definite method of work.

It is hoped that many of the papers read at both sessions will be published later. For the present, the following list of titles will serve to indicate their high quality.

FRIDAY, DECEMBER 28

(Joint Session with Section C)

Symposium, "The Chemistry of Metals."

"The Microscopic Structure of Metallic Alloys," by F. F. Lucas, Bell Telephone Laboratories, New York City.

"Elastic and Fatigue Failure of Metals," by H. F. Moore, University of Illinois, Urbana, Illinois.

"Chemical Specifications in the Metal Industry," by John Johnston, U. S. Steel Corporation, New York City.

"Corrosion of Metals—Surface Film Protection," by F. N. Speller, National Tube Company, Pittsburgh, Pa.

"Light Alloys in Aircraft Construction," by E. H. Dix, Jr., Aluminum Company of America, New Kensington, Pa.

SATURDAY, DECEMBER 29

Address of Retiring Vice-President, A. N. Talbot, University of Illinois, Urbana, Illinois.

"Research in the Engineers' Colleges," by W. E. Wickenden, Director of Investigation, Society for the Promotion of Engineering Education, New York City.

"A Naval Research Reserve," by Capt. C. S. McDowell, U. S. N., San Francisco, Calif.

"Photo-Electric Photometry," by Clayton H. Sharp, Technical Director, Electrical Testing Laboratories, New York City.

Symposium, "The Organization of Scientific Research in Industry."

"Finding and Encouragement of Competent Men," by F. B. Jewett, President, Bell Telephone Laboratories, New York City.

"Encouraging Competent Men to Continue in Research," by Willis R. Whitney, Director Research Laboratories, General Electric Co., Schenectady, N. Y.

"Economic Aspects of Research," by L. V. Redman, Director of Research, General Bakelite Corporation, New York City.

Summer School for Mechanical Engineering Teachers

THE 1929 session of the summer school for engineering teachers, conducted by the Society for the Promotion of Engineering Education, will be devoted to mechanical engineering and will be held at Purdue University from June 27 to July 18.

The summer school has for its purpose the improvement in methods of instruction in engineering colleges. The aim is to make the work of as definite value to the teachers as possible and to that end the sessions of each year are devoted to particular divisions of the curriculum. Since mechanical engineering is a broad division of engineering education, the program of 1929 is in part carried out in three divisions relating specifically to heat-power engineering, to machine design, and to production engineering.

The program begins with three days devoted to general meetings on such topics as the following: aims and purposes of mechanical engineering, present trends in higher education, purpose and scope of courses in heat power, machine design, and production, the history of mechanical engineering, general principles of teaching, and other topics relating to technical education in general and mechanical engineering in particular.

Following the first three days, the program is devoted to the three divisions previously mentioned. The heat-power division begins with the discussion of the teaching of general concepts and principles of thermodynamics, and proceeds through such subjects as properties of gases and vapors, gas and vapor cycles, flow of fluids, fuels and combustion, heat transfer, steam and power equipment, and the like. A definite sequence similar to that of the major course in heat power is followed so that the attending teachers may study methods of teaching the particular topics with which they deal in the classroom in logical order.

The machine-design division similarly follows a sequence relating to that division in mechanical engineering, including among others, analysis and transmission of motion, principles of kinematics, application of principles of mechanics in machine design, machine parts, design of machine tools, and materials of machine construction.

The production division deals with principles and methods of management, production control and personnel administration, and with the administration, aims, and purposes of engineering shop laboratory work. Considerable emphasis is being given to this portion of the program, not only in the division meetings but in the general sessions of the school. At intervals during the part of the program devoted to divisional meetings general sessions are held which include lectures on economics, cost control methods, management, laboratory instruction, and other general topics.

There will be a symposium devoted to the standardization in various branches of mechanical engineering, its importance and adaptation, which will be held under the auspices of the A.S.M.E. Standardization Committee.

For three days the entire group of teachers will move to Chicago as the guests of the Western Electric Company and will pursue an intensive program of lectures and inspections relating to the production, management, and personnel methods employed at the Hawthorne plant.

Upon return to Purdue University, the divisional and general meetings as above outlined are resumed. Toward the end of the session provision will be made for the submission and discussion of reports prepared by committees of members and staff relating to various problems of the teaching of mechanical engineering, such as, purposes and methods of heat-power courses for non-mechanical-engineering students, purposes and methods of design courses, purposes and methods of courses of administration and management, and the like. Considerable attention is to be given in this part of the program to mechanical-engineering laboratory work, including inspection of the Purdue laboratories, and to the study and discussion of methods pursued in conducting laboratory exercises.

The teaching staff of the school has been chosen, with the exception of one or two vacancies remaining to be filled, as follows: Local director, Dean A. A. Potter of Purdue University, secretary, H. L. Solberg of Purdue University, lecturers on educational principles and methods, C. H. Judd, director, School of Education, University of Chicago, Edward C. Elliott, president, Purdue University; heat-power division; Professors F. O. Ellenwood of Cornell, G. W. Munro of Purdue, W. J. Wohlenberg of Yale, C. H. Berry of Harvard, E. F. Miller of Massachusetts Institute of Technology, and C. F. Hirshfeld, chief, research department, Detroit Edison Co., and E. G. Bailey, president, Bailey Meter Co.; machine-design division; Professors O. A. Leutwiler, University of Illinois, R. C. H. Heck of Rutgers, H. F. Moore of University of Illinois, S. Timoshenko of University of Michigan, S. W. Dudley of Yale, and E. A. Muller, president, King Machine Tool Co., Francis Hodgkinson, consulting engineer, Westinghouse Elec. & Mfg. Co., C. B. Veal, research manager, Society of Automotive Engineers; production division, Dean D. S. Kimball of Cornell, Professors O. W. Boston of University of Michigan, F. C. Hockema of Purdue, J. W. Roe of New York University, and Messrs. L. P. Alford, vice-president, Ronald Press, E. Gruenwald, vice-president, Ross Gear Co.

Western Electric and other Bell System officials and engineers: C. L. Rice, vice-president and works manager; J. W. Bancker, vice-president in charge of purchasing and traffic; C. G. Stoll, operating vice-president; G. A. Pennock, assistant works manager; E. D. Hall, superintendent of assembly and inspection development; F. W. Willard, personnel director; H. C. Beal, superintendent of industrial relations; J. M. Starr, superintendent of accounting; D. Levenger, engineer of manufacture; W. L. Robertson, superintendent of manufacturing planning; J. R. Shea, superintendent of manufacturing development; E. M. Hicok, superintendent of production; W. O. Kurtz, general manager, Illinois Bell Telephone Co.; R. I. Rees, assistant vice-president, American Telephone and Telegraph Co.

General lecturers: G. M. Williams, president, Marmon Motor Car Co.; S. A. Lewisohn, vice-president, Miami Copper Co.; Richard Lieber, director, department of conservation, State of Indiana; G. A. Young, Purdue University; Ira N. Hollis, former president, Worcester Polytechnic Institute; John Johnston, director of research, United States Steel Co.; E. P. Warner, assistant secretary of the Navy for Aeronautics.

The school will be attended by seventy-five members from engineering schools in all parts of the United States and Canada and it is expected that about equal numbers will register for the three divisions of the program mentioned above. As in past years, all of the members of the school and of the staff will live together for the period of the session. Purdue University has set aside Franklin Cary Hall, one of the university dormitories, for the use of the party. The expenses of attendance, aside from traveling, include a registration fee of ten dollars and the cost of room and meals which will be forty-five dollars for the three weeks. The S.P.E.E. reports that some forty applications have already been received. Others may be sent to H. P. Hammond, Associate Director of Investigation, Society for the Promotion of Engineering Education, 33 West 39th Street, New York City. Professor Hammond is in general charge of the society's summer-school enterprise.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The Elements of Aviation

ELEMENTS OF AVIATION; AN EXPLANATION OF FLIGHT PRINCIPLES. By Virginius Evans Clark. Ronald Aeronautic Library, E. de F. Chandler, Editor, Ronald Press Co., New York, 1928. Cloth, 6 × 9 in., 193 pp., diagrams, $3.

REVIEWED BY FREDERICK M. HOPKINS, JR.[1]

WITH the increased interest in aviation on the part of the layman and the younger student, there has developed the need of an elementary treatise on the fundamental principles of flight and design. The author, a recognized authority in his field, has endeavored to satisfy this need. In the words of Major-General Mason M. Patrick, Retired, former Chief of Air Corps, U. S. Army, "The matter in this volume is clearly and logically arranged. It sets forth the basic, fundamental facts, the first principles of flight and design. The mathematical formulas are simple and easily understood, although the reader is properly cautioned that they are elementary, and that others, more complex, must be used by one who wishes to become a thoroughly trained aeronautical engineer."

The volume has no claim to originality other than the logical simplicity of its presentation. The numerous diagrammatic illustrations are well contrived. By comparisons with every-day knowledge, the author interprets the facts of simple aerodynamics in an easily read style.

The first chapters are devoted, naturally, to a discussion of the effects of air flow on airfoils. In a non-technical manner, the relation of air speed to the angle of attack, the theory of lift and drag, and pressure phenomena are treated. The explanation of burble, the theory of the wing-tip vortex and its effect on aspect ratio are discussed. Skin friction, boundary layer, and interplane interference are briefly mentioned.

The chapters on stability, control, and accelerated flight, full of apt comparisons, give a conception of the problems of dynamic and static stability. The use of elevators and ailerons in simple maneuvers is covered under "control." Power problems in accelerated flight, such as longitudinal balance with "power-off" and "power-on," slipstream effects on the fuselage, fins, and rudders, and propeller torque are explained. Power formulas under horizontal glide, climb, banking, landing, and taking-off conditions of flight are derived. The effect of change of air density with altitude and its resulting effect on speed, climb, and ceiling are discussed.

The remainder of the volume is a descriptive chapter of tendencies in the design and a summary of the weight ratios of the integral parts of the modern airplane. A set of definitions used in aeronautical design, aerodynamics, and mathematics is comprehensive and well included.

[1] First Lieutenant, Air Corps, U. S. A., Assistant Professor of Military Sciences and Tactics, New York University.

Books Received in the Library

A CORRECTION

On page 970 of the December issue in the review of The Technology of "Low-Temperature Carbonization" published by the Williams & Wilkins Co., Baltimore, Md., the price should have read $7.50 and not $2.

THE GREAT ENGINEERS. By Ivor B. Hart. Methuen & Co., London, 1928. Cloth, 4 × 7 in., 136 pp., illus., 3 s. 6 d.

After a description of engineering in classical times, Dr. Hart surveys the beginnings of engineering science in medieval times, particularly as exemplified by the work of Leonardo da Vinci and Agricola. Attention is then directed to the great engineers of more recent times who gave to us control over power and materials by developing the steam and gas engines and producing iron and steel. For such a brief work the book is an admirable survey of the development of engineering, told most attractively and clearly.

HISTORIC AIRSHIPS. By Rupert Sargent Holland. Macrae Smith Co., Philadelphia, 1928. Cloth, 7 × 10 in., 343 pp., illus., $4.

A popular account of early aviation, including the work of Santos-Dumont, the Wrights, and others; the first flights across the English channel; early attempts to cross the Atlantic and the American continent; Arctic flights; Lindbergh's achievement; and similar events.

INDUSTRIAL ORGANIZATION AND MANAGEMENT. By William B. Cornell. Ronald Press Co., New York, 1928. Cloth, 6 × 9 in., 653 pp., illus., graphs, forms, $5.

This textbook is intended to give engineers engaged in production and selling, and students of business, a knowledge of the fundamental principles of organization and management. The presentation is broad in scope and aims to reflect the most recent sound developments in this field.

JAHRBUCH 1928 DER DEUTSCHEN VERSUCHSANSTALT FÜR LUFTFAHRT, E. V., Berlin-Adlershof. R. Oldenbourg, Munich and Berlin, 1928. Cloth, 9 × 12 in., 274 pp., illus., diagrams, tables, 23 r.m.

The 1928 yearbook contains reports on the activities of the Versuchsanstalt during the year, and twenty-two technical reports of importance which have appeared previously as separate publications but are now collected in permanent form. In addition there are special reports upon large seaplanes, upon the Saxon exhibition of 1927, and upon the theory of screws. The technical reports cover a wide variety of problems relating to the construction and operation of aircraft, including those of radio communication, and give the results of much research work.

LAWS OF MANAGEMENT APPLIED TO MANUFACTURING. By L. P. Alford. Ronald Press Co., New York, 1928. Cloth, 6 × 9 in., 266 pp., $4.

The author of this work here attempts to formulate the fundamental principles of organization and management. Some fifty laws are given, which are believed to be basic, and each is discussed, with examples of its practical application. The book is based upon a paper presented before The American Society of Mechanical Engineers in 1926, here greatly amplified. It will be interesting to all executives and factory engineers.

MANUFACTURE OF PULP AND PAPER, vol. 4. Second edition. By Joint Executive Committee on Vocational Education representing the Pulp and Paper Industry of the United States and Canada. McGraw-Hill Book Co., New York, 1928. Cloth, 6 × 9 in., 260 pp., illus., tables, $6.

This volume of the course in paper manufacture, prepared by the pulp and paper industry of the country, takes up the manufacture of paper itself. The text is the work of many experts and gives an admirable account of the methods of paper making and of the general equipment of mills. The text is prepared for home study. This new edition has been extensively revised. Several sections have been rewritten and new topics included.

MANUFACTURING. By Malcolm Keir. Ronald Press Co., New York, 1928. (Industries of America.) Cloth, 6 × 9 in., 611 pp., illus., $5.

This work presents a picture of the development of manufacturing in America, from its beginnings to the present day. It attempts to show the part that manufacturing has played in our national economic structure, to show how it has influenced and been influenced by social progress, and to bring forward the relationships between manufacturing and other productive industries.

The major industries include iron and steel, automotive, meat, cotton, wool, silk, leather, shoes, paper, cement, brick, pottery, and glass. The development from household manufactures to the factory system is discussed, as well as labor problems. The work presents in readable style much material not readily available elsewhere.

MODERN FOUNDRY OPERATIONS AND EQUIPMENT. By William Rawlinson. Chapman & Hall, London, 1928. Cloth, 6 × 9 in., 312 pp., illus., tables, 18 s.

A survey of founding as practiced in the production of iron, steel, and non-ferrous castings. The principles underlying the various operations are emphasized rather than their practical and manual details. The relative values and applicability to various purposes of the metals commonly used are considered. Attention is given to the metallurgical considerations involved, and also to modern equipment.

ONE HUNDRED YEARS OF AMERICAN RAILROADING. By John W. Starr, Jr. Dodd, Mead & Co., New York, 1928. Cloth, 6 × 8 in., 336 pp., illus., $3.50.

A popular account of the beginnings of our great railroad systems. Starting with the earliest railroads in America, the book traces the advance of the railroad from east to west, and gives the history of the important lines in outline.

PRACTICAL FLYING: A Training Manual for Airplane Pilots. By Byron Q. Jones. Ronald Press Co., New York, 1928. Cloth, 6 × 9 in., 210 pp., illus., $3.

As chief of the Army aviation training during the World War, Major Jones had unusual opportunities to learn what is essential for the young aviator to know. In his book he attempts to answer the ordinary questions of the aspirant and also to give instruction in the details of flying.

After discussing the desirable physical and mental traits, the student is taken, step by step, through a course of practical instruction.

PRINCIPLES OF TRANSPORTATION. By Emory R. Johnson, Grover G. Huebner, and G. Lloyd Wilson. D. Appleton & Co., New York, 1928. Cloth, 6 × 9 in., 815 pp., charts, forms, $5.

This book deals with the business of transportation, as distinct from the mechanism by which the service is performed, and emphasizes the service rendered by the carriers and business principles rather than public policy and government regulation. Its most distinctive characteristic is that it brings within one book an account of rail, water, road, and air transportation and discusses them not only as separate services but as parts of a coordinated system.

PRODUCTION DESIGN. By J. K. Olsen. McGraw-Hill Book Co., New York, 1928. Cloth, 6 × 9 in., 212 pp., illus., tables, $3.

In designing for large-scale production, the designer must remember that any unnecessary operation or slight excess of raw material soon becomes an important waste, and that the largest possible tolerances will result in fewer scrapped parts, less trouble in production, and lower cost.

In this book the author discusses tolerances and allowances in fits, grinding, drilling, swaging, pile-ups, etc.; screw threads; raw materials for machines; heat treatment; and other topics pertaining to manufacture. His purpose is to present information which the production designer needs, but which he usually acquires only by long experience.

RECOVERY AND USE OF INDUSTRIAL AND OTHER WASTES. By John B. C. Kershaw. Ernest Benn, Ltd., London, 1928. Cloth, 8 × 10 in., 212 pp., illus., 25 s.

A survey of processes of recovery that have been proposed or used in a great variety of industries. Methods are given for use in machine shops, foundries, metallurgical works, and mines. Chapters are devoted to municipal wastes and to wastes in paper mills, tanneries, sugar factories, stockyards, rubber factories, and other industrial plants. The book brings much scattered information together and will be suggestive to any manufacturer.

SPANNUNGSKURVEN IN RECHTECKIGEN UND KEILFÖRMIGEN TRÄGERN. By Akira Miura. Julius Springer, Berlin, 1928. Paper, 6 × 9 in., 111 pp., illus., diagrams, tables, 11 r.m.

Although a knowledge of the exact distribution of the stresses in beams and other structural elements is of the highest importance, our information concerning it is still small, and current theory is admittedly not rigorously accurate.

Professor Miura has undertaken a new theoretical investigation of the distribution of stresses in beams. Two comparatively unknown curves, the isoclinic and the isochromatic, are used, by means of which the direction and magnitude of the principal stresses at any point can be determined. The theory is checked by optical investigations of glass models, and the results and methods are described.

STORY OF ENGINEERING IN AMERICA. By Chelsea Fraser. Thomas Y. Crowell Co., New York, 1928. Cloth, 6 × 8 in., 471 pp., illus., $2.50.

A popular account of American achievements in building roads, railroads, bridges, tunnels, subways, dams, reservoirs, canals, harbor improvements, lighthouses, mines, and buildings. The author succeeds in giving a good account of the development in each field and of the outstanding examples. The book can be recommended to boys interested in engineering, as well as to general readers.

THEORY OF FILM LUBRICATION. By R. O. Boswall. Longmans, Green & Co., London and New York, 1928. Cloth, 6 × 9 in., 280 pp., diagrams, tables, $5.

The purpose of this book is to give a detailed description of the mathematical principles that govern the operation of film lubrication, as established by Osborne Reynolds and later investigators, and to explain how these principles can be applied to the problems that arise in connection with the film lubrication of bearings. The author has brought together and correlated much material hitherto widely scattered, and arranged it in convenient form.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following page appear in the Management, Materials Handling, and Oil and Gas Power sections of A.S.M.E. Transactions as published in its new form. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

MANAGEMENT PAPERS

TRAINING MINOR EXECUTIVES IN A RAPIDLY GROWING ORGANIZATION. By A. J. Beatty. [Paper No. MAN-50-11]

In this paper the author discusses the problem of maintaining a trained working force in the rapidly expanding organization. The problem of the American Rolling Mill Company is used as an illustration of what may be accomplished through proper attention to the requirements of an expanding company and to the material available in the existing personnel. Two courses organized to replace the old Works' School of the company, namely, the Operating Training Course and the Sales Apprentice Course, are described. Other means of meeting new issues in the most effective manner are presented in the author's discussion of the Foremen's Cabinet and the Foremen's Forum, the former serving in an advisory capacity and the latter as an outlet to discussion. A valuable feature of the program of developing minor-executive talent is the Armco Foremen's Bulletin, which has served to stimulate interest in the project throughout the entire organization.

SYSTEMS OF WORKMAN PAYMENT IN PORCELAIN FACTORIES. By Hobart M. Kraner. [Paper No. MAN-50-12]

This paper describes the application of Standard Time and several other incentive systems as applied specifically to an electric porcelain plant manufacturing a wide variety of pieces. It points out the necessity of detailed study of the various operations in determining the applicability of the systems to these operations. It also points out the disadvantages of the simple piecework system so much used in porcelain plants where Standard Time and other such wage-payment plans have not been studied.

THE CONTROL OF QUALITY IN A MANUFACTURED PRODUCT. By James H. Marks. [Paper No. MAN-50-13]

In a brief discussion of his subject the author shows that the most important factors in accomplishing quality results are engineering as it carries out the design, and a trained personnel as it interprets the design in the finished equipment. The provision of adequate machines and tools is naturally important, but is secondary to the above-mentioned factors.

MATERIALS-HANDLING PAPERS

BULK-MATERIAL HANDLING AT DOCKS AND STORAGE PLANTS. By A. F. Case. [Paper No. MH-50-6]

In this paper the author, after briefly reviewing the historical side of the development of equipment for the handling of such materials as coal, ore, and limestone on the vast scale it is now carried on, gives particulars regarding car dumpers of both the lifting and revolving types, ore unloaders, and ore-handling bridges for storage work, as well as of their utilization on the Great Lakes and at Atlantic ports.

FUNDAMENTAL PRINCIPLES IN MATERIALS HANDLING. By Harold Vinton Coes. [Paper No. MH-50-7]

In this paper the author outlines briefly some of the fundamental principles of materials handling, which in their broadest aspects can be and should be recognized and applied to any industry where a materials-handling program is to be worked out. In the course of his discussion he deals with the absorption of the labor released by materials-handling machinery; the enormous toll due to handling and rehandling materials; facts of value in finding a correct solution of the problem; principles to be observed in installing materials-handling equipment; and advantages to be gained from properly selected and installed equipment. He then gives a list of instances where economies may be hoped for in the intelligent use of machinery instead of men, and points out a number of intangible benefits that directly accrue from the correct solution of shop-transportation problems. In conclusion he discusses the handling problem in the coal industry, giving labor cost data which show the possibilities of saving by the intensive application of mechanical-handling appliances.

A MATERIALS-HANDLING AND TRANSPORT ORGANIZATION. By C. A. Fike. [Paper No. MH-50-8]

This paper outlines briefly the organization which has in charge the materials-handling activities of the Westinghouse Elec. & Mfg. Co. at East Pittsburgh. It describes the equipment used, the operation of it and the methods of its control, and several of the wage-incentive plans which are used in the payment of the employees of the Plant Transportation Department. It concludes with a statement of some of the economies resulting from the organization described.

HANDLING METHODS AND EQUIPMENT IN A LARGE MAIL-ORDER HOUSE. By H. E. Odenath. [Paper No. MH-50-9]

With a mail-order house the chief object is speed and reliability of handling orders rather than cost reduction by eliminating waste motion or hand labor. In this paper the author describes the system employed by the firm with which he is connected in handling some 50,000 orders daily, ranging from small articles such as handkerchiefs to stoves and farm implements, and which often must be filled by contributions from many widely separated departments. Brief particulars are given of the methods used in bookkeeping, indexing filing, cashiering, and scheduling, following which the procedure employed in picking goods, assembling, wrapping, weighing, and stamping of merchandise for thousands of customers is described.

MODERN HANDLING IN ENAMELING WORK. By E. D. Smith. [Paper No. MH-50-10]

The author describes change from the hand- or push-truck method of handling in the enameling department of the National Cash Register Co., which resulted in a reduction in payroll, an increase in production of 33 per cent, a saving in floor space, a reduction in number of handlings from 58 to 20, improved quality of production, a reduction of turnover time from $3^1/_2$ to $1^1/_2$ days, and a reduction of inventory of cabinets and parts of 80 per cent.

OIL AND GAS POWER PAPERS

MANUFACTURE OF DIESEL FUEL INJECTORS. By C. R. Alden. [Paper No. OGP-50-7]

This paper deals with details of design and manufacture of parts of fuel-injection pumps, such as plungers and their bushings and check valves, which must be made with greatest precision in order to

permit the injection of an accurately metered amount of oil and to be tight against high pressures. Results of tests to determine the length of bushing necessary to prevent leakage around a plunger are reported, and show that this need be much less than is usually specified. The characteristics of materials from which such parts can be manufactured are also given. It is suggested that the parts considered may be easily standardized with benefit to the oil-engine manufacturer.

EUROPEAN DIESEL-ENGINE DEVELOPMENTS. By Oliver F. Allen. [Paper No. OGP-50-8]

This paper, which is profusely illustrated, first reviews briefly the history of the Diesel engine. It then discusses the growth of the industry in Europe, following which it outlines what has been accomplished with solid injection, including automotive work, and with supercharging. The development of the double-acting engine is next described, and in conclusion the latest tendencies in power-station and marine work are referred to.

COOPERATIVE DIESEL-ENGINE RESEARCH. By Harte Cooke. [Paper No. OGP-50-9]

After describing the early development of the Diesel engine and showing its widespread use in industry and transportation, the author states that its main problems are now solved and that its present status is the same as that of the steam engine and turbine. An advance could be made, however, if more complete information could be obtained through research in regard to such fundamentals as the nature of the combustion, the characteristics of the products of combustion at the high temperatures and pressures involved, the characteristics and nature of the ignition at these high temperatures and pressures, transfer of heat from mixture to walls, and through walls to the water jackets, the question of weight, etc. The author then refers to several successful examples of cooperative research, and concludes that the problem of Diesel-engine research would be best solved by having the industry as a whole cooperate in supporting such research, which could best be conducted by such a disinterested body as the A.S.M.E.

DIESEL-FUEL-OIL SPECIFICATIONS. By G. H. Michler. [Paper No. OGP-50-10]

The author gives examples of the various specification requirements encountered by the oil refiners, and points out the impossibility of carrying several grades of Diesel fuel oil at distributing points which are not also refining centers. Unless Diesel engines are constructed which can operate efficiently on a standard grade of oil of broad specification, ship operators will be unduly restricted to limited points of fuel supply and may be precluded from operating in the most desirable trade services. He suggests that three specifications would be sufficient: a minimum gravity of 24 deg. A.P.I., a maximum sulphur content of 1.5 per cent, and a minimum flash of 150 deg., closed cup.

THE ECONOMIC FIELD FOR LARGE DIESEL ENGINES. By Edward B. Pollister. [Paper No. OGP-50-11]

The author defines a large Diesel engine as one ranging from 2500 to 25,000 hp. He cites the successful performance of marine Diesels, and gives figures showing that the aggregate horsepower of such engines now being built or installed is over three times that of marine steam turbines. He points out territory far removed from coal mines and where a cheap supply of fuel oil makes the use of the Diesel engine especially desirable. Over half of the fuel oil consumed in generating electric power, he states, could be saved by burning it in Diesels rather than under boilers. Diesel generating stations cost about the same as modern steam plants, around $135 per kw. Diesels have characteristics which especially fit them for use as auxiliaries in steam and hydroelectric power plants. The paper concludes with a brief consideration of the use of large Diesel engines in industrial plants.

OIL-SPRAY RESEARCH AT PENN STATE. By P. H. Schweitzer. [Paper No. OGP-50-12]

One of the major objects of the Engineering Experiment Station of the Pennsylvania State College is an experimental investigation of fuel-injection phenomena. The main object of the investigation is to establish the laws that control the characteristics of oil sprays in compressed air under various conditions encountered in the injection type of oil engines. The elaborate equipment of apparatus, which is perhaps unexcelled anywhere and which has taken four years to assemble, is described and illustrated in the paper.

SPECIALIZATION IN MANUFACTURING DIESELS. By O. D. Treiber. [Paper No. OGP-50-13]

While the Diesel-engine industry has today a very wide range of specialty products to draw from, such as bearings, piston rings, crankshafts, valves, cams, springs, etc., there are nevertheless many other parts which could be made economically in specialty shops, and the author believes that the Oil and Gas Power Division could profitably classify Diesel-engine parts into groups and make recommendations that would benefit both the engine builder and the specialty manufacturer.

THE DIESEL ENGINE AND PUBLIC UTILITIES. By Roswell H. Ward. [Paper No. OGP-50-14]

The problem of the relationship between the Diesel-engine industry and the public utilities, the author states, is one which deserves the careful consideration and dispassionate scrutiny of all concerned. The conflicting points of contact seem to be (1) public-utility use of Diesel power; (2) competition between the Diesel industry and the utility companies for industrial load; and (3) competition for municipal projects. The author discusses these points one by one and shows how they all are due to a series of minor misunderstandings to which a number of very logical answers immediately suggest themselves.

NOTE: Those who have not registered in the A.S.M.E. Management, Materials Handling, and Oil and Gas Power Divisions, whose papers are abstracted on this and the previous page, and who desire copies of any of these papers, may obtain them by using the form given below.

TO THE SECRETARY, A.S.M.E., 29 West 39th Street, New York, N. Y. Date.....

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THE ENGINEERING INDEX

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Mechanical Engineering Section

THE ENGINEERING INDEX furnishes a Weekly Card Index Service of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Items of particular interest to mechanical engineers are selected for presentation each month in this Mechanical Engineering Section. In operating The Engineering Index, The American Society of Mechanical Engineers makes available the information contained in some 1700 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

AIRPLANE ENGINES

Berlin Exhibition. New German Aero Engines, E. P. A. Heinze. Aero Digest, vol. 13, no. 6, Dec. 1928, pp. 1168, 1170 and 1172, 8 figs. New German engines exhibited at International Aircraft Show in Berlin are described; B.M.W. leading with Junkers second, and Siemens and Halske third. Details of one new water-cooled 12-cylinder and two 6-cylinder B.M.W. engines, 6-cylinder and 12-cylinder V water-cooled Junkers engines, Siemens-Halske air-cooled radial engines, Daimler-Benz 12-cylinder V water-cooled and 3-cylinder water-cooled engines, and Argus two 12-cylinder inverted V engines.

Cowling. Drag and Cooling With Various Forms of Cowling for a "Whirlwind" Engine in a Cabin Fuselage, F. E. Weick. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 301, Nov. 1928, 25 pp., 35 figs. on supp. plates. Results of investigation in 20-ft. propeller tunnel on engines entirely exposed up to completely cowled types; cooling tests made and cowling modified; drag tests; great drag in uncowled engine; effect on airplane performance; cowling entirely covering engine reduces drag 2.6 times conventional cowling; careful design for proper cooling; with cabin fuselage its use should substantially increase high speed.

The New N.A.C.A. Low Drag Cowling, F. E. Weick. Aviation, vol. 25, no. 21, Nov. 17, 1928, pp. 1556–1557, 1586, 1588 and 1590, 6 figs. Wind-tunnel tests undertaken by National Advisory Committee for Aeronautics on different designs of cowling on air-cooled engines; enormous drag due to uncowled engine; conventional cowlings covering only central portion of engine only slightly reduced drag; new cowling of N.A.C.A. design completely enclosed engine but provided for cooling; great reduction in drag in wind-tunnel and flight tests; substantial increase in high speed and all-round performance.

Problems. Problems of Aircraft Engines (Flygmotorproblemet), E. Hubendick. Ingenioers Vetenskaps Akademien (Stockholm), no. 84, 1928, 34 pp., 29 figs. Account of problems of aircraft engines; J. E. Cederblom's research work on ideal aircraft engine; climatic conditions of Scandinavia call for special measures for cooling and starting; adaptation of Diesel engine for aircraft; possibilities in design conditioned by new materials, etc.

AIRPLANES

Autogiro. The Autogiros of Cierva (L'autogire de la Cierva), M. Ducout. Aérophile (Paris), vol. 36, no. 19–20, Oct. 1928, pp. 295–298, 7 figs. Cierva autogiro has carrying surface of 11 sq. m.; total weight 1120 kg.; motor 220 hp.; theory of design; rotation of lifting screw; speed of air relative to blade and forces applied; speed of autogiro.

The Cierva Autogiro, W. H. Sayers. Aviation, vol. 25, no. 18, Oct. 27, 1928, pp. 1320–1321, 1340–1342, 1344 and 1350, 8 figs. Aerodynamic principles involved in design and operation of this craft are discussed; all autogiros so far have standard airplane fuselage, landing gear and tail unit; rotating system of supporting surfaces in place of wings; ailerons are separate organs carried on each side of fuselage; blades in addition to rotating, move up and down; speed of vane system constant; auxiliary drive being developed will allow spinning up of rotating wings directly by main engine.

Control. Research on the Control of Airplanes, B. M. Jones. Nat. Advisory Committee for Aeronautics—Tech. Memorandum, no. 485, Oct. 1928, 23 pp., 9 figs. on supp. plates. Controversy between theory of airplane with control organs and uncontrolled stable airplane; provision of good control qualities is more a question of proportioning airplane and adjusting its load than of new control organs; motions of stalled airplanes studied by Cambridge University Air Squadron; great influence of yawing motions on rolling couples; ailerons positive source of danger; rudder provides control difficult to use; solutions offered. From Nature (Lond.), May 12, 1928. Lecture delivered at Royal Instn.

Design Stresses. Design Stresses, C. D. Holland. Flight (Lond.), vol. 20, no. 43, Oct. 25, 1928, (Aircraft Engr.) pp. 936f-936g, 3 figs. Design stress defined as maximum stress material will be subjected to when structure is loaded to amount of load factor times normal load; determining tension, pure compression, compression for long struts, shear, bearing, Young's modulus, modulus of rigidity, and Poissons' ratio; effect of workshop processes on normal design stresses of materials; effect on design-stress value due to different types of loading.

Performance Testing. The Reduction of Performance Tests, H. L. Stevens. Roy Aeronautical Soc.—Jl. (Lond.), vol. 32, no. 215, Nov. 1928, pp. 934–957, 11 figs. and (discussion) 957–958. Computing work necessary between receipt of performance figures from pilots and issue of complete report; method adopted for all but supercharged engines assumes power depends on pressure only; affects of atmospheric temperature on altimeters and air-speed indicators; correction of air-speed readings for propeller-efficiency correction; density method for correcting performance tests of supercharged engines; pressure methods explained.

Spinning Characteristics. The Spinning of Airplane, M. Watter. Aero Digest, vol. 13 no. 5, Nov. 1928, pp. 912, 914 and 916, 2 figs. Spinning and efforts directed toward explaining it; spinning sometimes considered desirable maneuver in combat; aerodynamical and dynamical causes of spinning; mastery lies in reliable means of recovery and not in prevention; increase in size of stabilizing and controlling surfaces only temporary remedy; possibility of using automatic leading edge slots on horizontal tail surfaces; rudder action is of utmost importance in spinning and efforts should be directed to increase its efficiency by preventing its shielding; inclination of rudder axis suggested.

Wing Design. A New Method of Stress Calculation of Monoplane Wings, S. Kaneko. Tokyo Imperial Univ.—Jl. (Tokyo), vol. 17, no. 12, Oct. 1928, pp. 213–244, 22 figs. General equations for deflection and torsion of wing and expressions for stresses in its structure; actual strength of monoplane wing is widely different from results obtained by conventional method of stress calculation; it must be calculated from combined considerations of deflection and torsion of wing as whole; problems solved for special cases; comparison of numerical results obtained by present method and by conventional one. (In English.)

AIRSHIPS

Rigid. Airship R. 101. Flight (Lond.), vol. 20, no. 47, Nov. 22, 1928, pp. 997–998. Single-line diagrams stressed by Royal Airship Works and geometry and load used by Boulton and Paul to convert line diagram into actual structure; airship is compromise between perfect aerodynamic shape and practical manufacturing possibilities; very fundamental differences between R. 101 form of construction and that of Zeppelin; accuracies to which manufacturers had to work; some dimensions show magnitude of task.

ALLOY STEELS

Temperature Effect. Effect of Alloying Elements Upon the Stability of Steel at Elevated Temperatures, A. E. White and C. L. Clark.

NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

Am. Soc. Mech Engrs.—Advance Paper, no. 35, for mtg. Dec. 3–7, 1928, 21 pp., 54 figs. Short-time tensile tests were conducted on large number of alloy steels, chemical composition of which is given; advances theory or hypothesis accounting for stability of various types of steels at elevated temperatures, and gives specific data on various types of steels when in annealed or normalized state, and effect of heat treatments.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Bearing Metals. See BEARING METALS.

Brass. See BRASS.

ALUMINUM ALLOYS

Castings. The Production of Non-Porous Castings of Aluminum Alloys (Zur Kenntnis der Erzeugung gasporenfreier, dichter Gusstuecke aus Aluminium-Legierungen), W. Claus and E. Kalaehne. Giesserei (Duesseldorf), vol. 15, no. 40, Oct. 5, 1928, pp. 996–1000, 12 figs. Discussion of cause of gas porosity; results of tests with "Y"-alloy (1.5 per cent magnesium, 2 per cent nickel, 4 per cent copper, 92.5 aluminum); tests were also carried out on so-called "American" alloy (copper 8 per cent, aluminum 92 per cent).

AUTOMOBILE ENGINES

Crankless. Swashplate Replaces Crankshaft in Michell Five-Cylinder Automobile Engines, P. M. Heldt. Automotive Industries, vol. 59, no. 21, Nov. 24, 1928, pp. 767–769, 5 figs. Details of crankless engine invented by A. F. M. Michell, which is said to have absolute running balance and to be simpler, lighter, and more compact than other types; it can be built in single or double-ended form; bearings between swashplate and slippers which communicate piston motion to it, embody same principle of oil wedge as does Michell thrust bearing; swashplate and its related parts form substitute for crank train; five cylinders in single casting; chattering prevented.

Design. High-Speed High-Efficiency Engines, F. S. Duesenberg. Soc. Automotive Engrs.—Jl., vol. 23, no. 6, Dec. 1928, pp. 589–592 and (discussion) 592–594. Marked improvement in these engines predicted during next few years; main features of design of author's 91-cu. in. racing-car engine and its parts, and on troubles that necessitated design changes; unless manifold can be perfected so that double carburetion becomes practicable there is no means of obtaining correct air-fuel mixtures at all speeds; valve area is controlling factor for high speed unless supercharger is used.

Two-Stroke vs. Four-Stroke Cycle (Zweitakt oder Viertakt), P. Friedmann. Allgemeine Automobil-Zeit. (Berlin), vol. 29, nos. 44 and 45a, Nov. 3 and 11, 1928, pp. 24–25 and 46–47, 8 figs. Discussion of advantages and disadvantages of 2-stroke and 4-stroke cycle engines from mechanical, dynamic and thermal viewpoints; climbing capacity; it is concluded that both have their merits and weaknesses.

Fuel Pumps. Biflex Fuel Pump. Automotive Industries, vol. 59, no. 21, Nov. 24, 1928, pp. 765–766, 2 figs. New type of fuel pump, built around Sylphon metal bellows and made by Biflex Products Co., Waukegan, Ill., is described; fuel is received inside bellows on intake stroke or when bellows are expanded, and is forced to carburetor on exhaust stroke or when bellows are contracted.

Eliminating the Carburetter. Autocar (Lond.), vol. 61, no. 1725, Nov. 23, 1928, p. 1187, 2 figs. Novel system of fuel distribution by means of which heavy oil can be used as fuel on car engines of normal type; system patented by A. V. Rutzebeck; device consists of small diaphragm pumps, one of which is mounted on combustion head of each cylinder, and mouth-pieces or injection nozzles are likewise fitted into each combustion chamber, or alternatively one mouthpiece is located centrally inside induction manold.

AUTOMOBILE PLANTS

Machine Tools. Many Highly Specialized Jobs Now Being Performed With Standard Machine Tools, K. W. Stillman. Automotive Industries, vol. 59, no. 20, Nov. 17, 1928, pp. 694–705, 45 figs. Examples taken from production lines of representative automotive companies; tapping cylinder blocks; special drilling machine; finishing gear housings; grinding beveled pinions; gear shapers; internal splining; chucking grinder adapted; surface grinder uses; rotary-type work table; wide-wheel grinding; two Houde methods; set-up for spark plugs; special rotary fixture; grinding clutch sleeves; high-precision boring.

AUTOMOBILES

Clutches. A New Clutch Design. Automobile Engr. (Lond.), vol. 18, no. 248, Nov. 1928, p. 452. Combined cone-and-plate clutch to secure smooth and positive engagement, designed by Auto Engineering and Car Co.; engine flywheel internally coned and inner driven clutch member is fabric-faced cone which carried pressure plate, also fabric-faced which makes contact with machined face of flywheel.

The N.A.G. Automatic Clutch. Motor Transport (Lond), vol. 47, no. 1236, Nov. 19, 1928, p. 616, 7 figs. Details of automatic clutch introduced by Nationale Automobil Gesellschaft, Berlin which attracted considerable attention in private-car section of Berlin show; its action is automatic to allow ordinary pressure springs of clutch to engage friction surfaces, and therefore take up drive, when engine speed rises above 400 to 600 r.p.m.

Production Costs. How the Ford Company Gets Low Production Costs, J. Younger. Soc. Automotive Engrs.—Jl., vol. 23, no. 6, Dec. 1928, pp. 568–570. Economic factors applying to mass production are dealt with to show how, by following certain laws of manufacturing management based on economic laws, Ford Motor Co. has attained its very low production costs; some of these laws, put into concrete form as recently as 1926 by L. P. Alford, are quoted, and examples of methods are given to show how they operate; conveyors are pace setters; no intermediate profits taken; principles applied to machine tools. See also Machy. (N. Y.), vol. 35, no. 4, Dec. 1928, pp. 248–249.

Transmissions, Automatic. The de Lavaud Automatic Transmission, D. S. de Lavaud. Soc. Automotive Engrs.—Jl., vol. 23, no. 6, Dec. 1928, pp. 571–579 and (discussion) 579–582. Transmission consisting of wabble plate which actuates six connecting rods operating as many roller clutches on rear axle, is described; changes in speed result from varying inclination of wabble plate, and this is controlled automatically through combined effects of inertia and reaction of resistance; criticisms of increased complication and expense, increased unsprung weight, predicted short life for one-way clutches, and rendering engine unable to act as brake, are answered by author; summary of automatic action.

AUTOMOTIVE FUELS

Synthetic. Synthetic Motor Fuels, M. Hugel. Automotive Industries, vol. 59, no. 20, Nov. 17, 1928, p. 693. Results of experiments on catalytic hydrogenation of tar pitch carried out by author; high-pressure hydrogenation process of Bergius is applicable to pitch; hydrogenation of pitch takes place under pressures of 1100–1400 lb. per sq. in. at temperatures of 575 deg. fahr., in presence of from 7 to 10 per cent of catalytic material. Abstract of paper presented before Congress of Industrial Chemistry at Strasbourg.

Status of Substitute Motor Fuels, G. A. Burrell. Oil and Gas Jl., vol. 27, no. 22, Oct. 18, 1928, p. 56. Discusses several products now available, manufactured from variety of raw materials; gasoline deemed in no immediate danger from competition of substitutes, high cost of ethyl alcohol; methyl alcohol cheap, but is poisonous and has tendency to pre-ignite; benzol gives mileage 18 per cent above gasoline, but supply is limited; hydrogenation; shale oils; future of heavy oils, with development of lightweight engines of Diesel type.

B

BEARING METALS

Bronze. Wear and Mechanical Properties of Railroad Bearing Bronzes at Different Temperatures, H. J. French, S. J. Rosenberg, W. L. Harbaugh and H. C. Cross. U. S. Bur. Standards—Jl. of Research, vol. 1, no. 3, Sept. 1928, pp. 343–421, 62 figs. partly on supp. plates. Bronzes were tested under rolling and sliding friction without lubrication at atmospheric and elevated temperatures; under tension impact, and pounding at temperatures from 70 to 600 deg. fahr.; detailed description is given of all apparatus used in tests.

White-Metal. White Metal Alloys for Bearings, their Treatment and Micostructure, O. G. Styrie. Eng. Progress (Berlin), vol. 9, no. 11, Nov. 1928, pp. 318–320, 5 figs. White metal is only for non-adjustable bearings; researches of Bauer and Heyn on bearing alloys, especially ternary tin–antimony–lead system, showed new ways to improve this alloy by adding copper; this quaternary alloy is basis for bearing-metal standards established by German Standards Committee; low percentage tin alloy, known as "Thermit"-Brand anti-friction metal, consists chiefly of lead hardened by adding constituents with high melting point, such as nickel.

BEARINGS, BALL AND ROLLER

Heavy-Duty. Heavy-Duty Anti-Friction Bearings, S. G. Koon. Am. Soc. Mech. Engrs.—Advance Paper, no. 19, for mtg. Dec. 3–7, 1928, 11 pp., 12 figs. Advantages of ball or roller bearings on almost all types of operating mechanisms are stressed; limitations to use of bearings, particularly those dealing with space limitations on equipment of old design; concurrent development of heavy-duty bearings for steel-rolling-mill work; features of operating conditions found in steel mills lubrication and care of bearings are also given consideration.

BEARINGS, JOURNAL

Friction. Friction of Journal Bearings as Influenced by Clearance and Length, S. A. McKee and T. R. McKee. Am. Soc. Mech. Engrs.—Advance Paper, no. 21, for mtg. Dec. 3–7, 1928, 6 pp., 11 figs. Investigation at Bureau of Standards is described, object of which was to determine effects upon frictional resistance of small-bore full-journal bearings of changes in length-diameter and clearance-diameter ratios; results indicate that changes have marked effects upon frictional characteristics of journal bearings in normal operation; further steps toward more complete understanding of journal-bearing performance are indicated.

Running Positions. Journal Running Positions, H. A. S. Howarth. Am. Soc. Mech. Engrs.—Advance Paper, no. 13, for mtg. Dec. 3–7, 1928, 10 pp., 15 figs. Impression has gained ground that under no circumstances will journal rise higher than bearing center in any clearance bearing, if classic theory is correct; 120-deg. bearing was chosen for present study because it approximates bearings widely used in steam turbines; load direction upon partial bearing has amazing influence upon running position of journal and no matter how high above bearing center journal may run at any finite speed, it will return to run concentric with bearing at infinite speed.

BLAST FURNACES

Heat Accumulators. Mathematical Theory of Heat Accumulators (Mathematische Theorie der Waermespeicher), W. Schmeidler. Zeit. fuer Angewandte Mathematik und Mechanik (Berlin), vol. 8, no. 5, Oct. 1928, pp. 385–393. Mathematical theory of heat accumulators used in blast-furnace operation, etc., involves system of Volterra integral equations; author presents simplified approximate method of analysis.

BOILER FEEDWATER

Treatment. Boiler Feedwater Treatment Advances Toward Status of Exact Science, J. A. Holmes. Chem. and Met. Eng., vol. 35, no. 11, Nov. 1928, pp. 695–696, 3 figs. In internal treatment, use of zeolites for waters containing majority of sulphates and fairly low alkalinity is general; for internal treatment Hall's system has given impetus for more careful research; Parr and Straub have developed their work on embrittlement of boiler plate to point where its cause and control is fairly well established; theory of coagulation; work of Koyl and Foulk.

Fundamental Principles of Feedwater-Treatment Processes for Boiler Plants (Grundsaetzliches ueber die Verfahren zur Speisewasseraufbereitung fuer Dampfkesselanlagen), H. Balcke. Waerme (Berlin), vol. 61, no. 40, Oct. 6, 1928, pp. 747–752. Article discusses in critical manner behavior of chemical and evaporating processes, their advantages and disadvantages in operation of steam power plants.

Practical Points on Feed Water Treatment, J. Guest. Blast Furnace and Steel Plant, vol. 16, no. 11, Nov. 1928, pp. 1461–1465, 1 fig. Various methods of treatment are reviewed, both with regard to results attained and routine application; treatment with lime and soda for removing scale-forming solids; chemical treatment applied by both hot and cold processes, both continuous and intermittent in operation; hot process is more rapid, in general, and smaller tanks are necessary than with cold processes; design of tanks; removal of precipitators; zeolites; operating costs.

Salt and Sludge Removal from Boiler Feedwater (Entsalzung und Entschlammung des Kesselwassers), H. Manz. Waerme (Berlin), vol. 51, no. 40, Oct. 6, 1928, pp. 726–732, 5 figs. Calculation is given of changes in concentration of soluble salts and sludge in feedwater brought about by boiler operation, and discussion of means of reducing salt and sludge content; their influence on boiler efficiency.

BOILER FURNACES

Walls. Combustion Chamber Wall Design. Eng. and Boiler House Rev. (Lond.), vol. 42, no. 5, Nov. 1928, pp. 248, 250 and 252, 3 figs. Requirements of ideal furnace-wall construction are enumerated and details given of Bailey wall construction, main feature of which is its great strength to withstand fluxing action of ash and to reduce to lowest possible figure costs of furnace maintenance; it also provides additional heating surface.

BOILERS

Design. Steam Economics and Boiler Practice (Dampfwirtschaft und Dampfkesselwesen), O. Koester. Stahl und Eisen (Duesseldorf), vol. 48, nos. 43 and 44, Oct. 25 and Nov. 1, 1928, pp., 1497–1505 and 1537–1543, 22 figs. Outline of advantages of application of high steam pressure and temperatures, intermediate superheating, and feedwater preheating by means of bled steam; factors are discussed which led to radical change in boiler design, such as air preheating, utilization of radiation heat, and introduction of pulverized-coal firing.

Drums. Boiler Drums for the Largest 1200-Lb. Power Plant Go Through the Shop, J. McQuillan. Power, vol. 68, no. 24, Dec. 11, 1928, pp., 950–953, 10 figs. Plant at Deepwater, N. J., will have initial installation of two units of approximately 120,000 kw. and will have 4 Babcock and Wilcox primary boilers and 2 B. & W. reheater boilers each boiler having effective heating surface of 9078 sq. ft., and capacity of 330,000 lb. of steam per hr.; six boiler drums are 50 ft. 3 in. long, by 52 in. inside diam., and 60 in. outside diam., made of open-hearth steel; method of forging and finishing drum.

Weldless Steel Drums for High-Pressure Boilers. Engineering (Lond.), vol. 126, no. 3281, Nov. 30, 1928, p. 676, 9 figs. partly on supp. plate. Particulars of two drums of exceptional size made by Vickers-Armstrongs, Ltd.; larger measures 44 ft. 5 in. in length, while outer diameter is 5 ft. 3 in. and wall thickness 4½ in.; material used is acid open-hearth steel; ingot which drums are forged weighs 165 tons; forging process is described.

High-Pressure. Brown Boveri High-Pressure Steam Boiler. Eng. and Boiler House Rev. (Lond.), vol. 42, no. 2, Aug. 1928, pp. 80 and 82, 2 figs. Design consists essentially of series of superheaters and evaporators, superheated steam being utilized to generate saturated steam which in turn is superheated; purpose of this design is to overcome difficulties in designing direct-fired high-pressure boilers, and to give more flexible unit as regards responding to sudden variations of load demand; not intended to place this boiler on market.

High-Pressure Boiler with Indirect Heating of the Schmidtsche Heissdampf-Gesellschaft (Hochdruckkessel mit mittelbarer Beheizung der Schmidtschen Heissdampf-Gesellschaft), B. Schapira. Feuerungstechnik (Leipzig), vol. 16, no. 17, Sept. 1, 1928, pp. 196–198, 3 figs. Author points out disadvantages of existing boilers for pressures of 50 atmos. upward; new boiler has indirect heating with forced circulation without circulating pump; in narrow coiled pipe exposed to flame, steam is generated from distilled water in two stages; if pipe bursts, no serious damages can occur.

Recording Instruments. An Optical Recorder of Combustion Conditions. Eng. and Boiler House Rev. (Lond.), vol. 42, no. 2, Aug. 1928, pp. 69–70, 2 figs. "Lumograph," made by firm of Karl Priem of Frankfurt-Oder, as recording stop watch for timing operations of any description; it provides continuous record of luminosity of flame at appropriate point in combustion chamber, and it is claimed that this record makes possible important savings of fuel, particularly in hand-fired boilers, while affording suitable basis on which to calculate stokers' bonuses.

Water Tube—Testing. Forced-Blast, Chain-Grate Stoker Tests of Marine Watertube Boiler, T. B. Stillman. Mar. Eng. and Shipg. Age, vol. 33, no. 12, Dec. 1928, pp. 642–646 and (discussion) 672–673, 4 figs. Object of conducting tests reported was to develop methods for satisfactorily and efficiently utilizing coal as fuel under marine water-tube boilers, without requiring heavy manual labor involved in hand firing; Babcock & Wilcox marine type originally fitted for hand firing; flexibility for maneuvering. Paper read before Soc. Naval Arch. and Mar. Engrs.

BRASS

Nickel. Nickel Brasses, A. C. Sturney. Metal Industry (Lond.), vol. 33, no. 21, and 22, Nov. 23 and 30, 1928, pp. 485–488 and 494, and 521, 2 figs. Brief description of graphical method by which properties of ternary system of nickel brasses are best represented; copper-zinc-nickel system; properties of nickel silvers, effects of impurities and suggestions concerning foundry practice; pouring temperature; nickel high-tensile brasses; quaternary nickel brasses, known principally as manganese bronzes; properties of chill-cast specimens. Bibliography. Paper read before Scottish Local Sections of Inst. of Metals.

Hot Rolling of. Hot Rolling of Alpha Brass, K. N. Kadmov. Vestnik Metallopromyshlennosti (Moscow), vol. 8, no. 9–10 Sept.–Oct. 1928, pp. 171–182, 13 figs. Report of experimental study made at Kolchugin plant and at laboratories of Moscow Institute of Mining, proving feasibility of hot rolling of brass containing 65 to 67 per cent copper, provided lead impurities are absent. (In Russian.)

C

CABLEWAYS

Passenger, Italy. Aerial Funiculaire from Oropa to Lake Mucrone (Le funiculaire aérien d'Oropa au lac de Mucrone). Revue Générale de l'Électricité (Paris), vol. 24, no. 19, Nov. 10, 1928, pp. 715–716. Description of cableway 2400 m. long; difference of level 653 m.; maximum span 1122 m.; two supporting cables, 40 mm. diameter; electric equipment and operation; speed 3.6 m. per sec.; cars carry 16 passengers.

CARBURETORS

Internal-Combustion Engines. Theory and Design of New Carburetor, M. Isikawa. Tokyo Imperial Univ.—Report (Tokyo), vol. 4, no. 43, Sept. 1928, 67 pp., 20 figs. Article deals with fundamental course of design of new carburetor, consisting of coke tube of Venturi type and fuel diffuser which is substitute for fuel-spray nozzle of simplest jet-in-tube carburetor; design of experimental model; experiments on metering characteristic of model carburetor. (In English.)

CASE HARDENING

Depth of Case. Depth and Character of Case Induced by Mixtures of Ferro-Alloys With Carburizing Compounds, E. G. Mahin and R. C. Spencer. Am. Soc. Steel Treating—Advance Paper for mtg., Oct. 8–12, 1928, 26 pp., 14 figs. Experiments show that if silicon absorption is confined to surface layers of iron or steel, carbon absorption during case carburization may be retarded without materially affecting rate of inward migration of carbon after it has been absorbed; deep case produced without zone of free cementite, by using ordinary carburizer in conjunction with ferrosilicon and by employing higher carburizing temperatures, thus shortening time required.

Nitration. A New Method of Nitrogen Case Hardening, G. F. Bason. Am. Soc. Steel Treating—Trans., vol. 14, no. 6, Dec. 1928, pp. 932–934. Investigation of hardening of collector rings on electrical machinery; it is believed that this hardening may be due to ring being bombarded with nitrogen ions, thereby nitrogenizing surface of steel; it is suggested that this process be more or less closely imitated as possible means of evolving practical method of nitriding superior to present ones.

CAST IRON

Heat Treatment. The Heat Treatment and Volume Changes of Grey Cast Irons between 15 deg. and 600 deg. C., J. W. Donaldson. Foundry Trade Jl. (Lond.), vol. 39, no. 636 and 637, Oct. 25 and Nov. 1, 1928, pp. 299–303 and 315–318, 22 figs. Oct. 25: Author carried out numerous investigations on materials for internal-combustion engines; cast iron is very complex and one of least understood materials as regards constitution and properties under varying temperatures; influence of heat treatment on decomposition of combined carbon, strength, and hardness; method of testing. Nov. 1: Volume changes between 15 and 600 deg. cent. Paper presented to Assn. Technique de Fonderie.

CHROMIUM PLATING

Applications. Mechanical Applications of Chromium Plating, W. Blum. Am. Soc. Mech. Engrs.—Advance Paper, no. 6, for mtg. Dec. 3–7, 1928, 6 pp. After giving particulars regarding physical properties of chromium, author discusses application of chromium plating to gages and other measuring devices; to drawing, forming, stamping, and molding dies; rolls for forming metals; tools for cutting metal; to bearing surfaces in machinery, etc.; savings due to longer life of chromium-plated tools and parts, and reduced number of times that machines must be stopped for replacement.

CHROMIUM STEEL

Anti-Corrosive. A New Development in Corrosion Resisting Steel, F. R. Palmer. Am. Soc. Steel Treating—Trans., vol. 14, no. 6, Dec. 1928, pp. 877–888 and (discussion) 888–892 and 950, 7 figs. Paper points out satisfactory means for improving machinability and grinding properties of high-chromium corrosion-resisting steels; effect of phosphorus and sulphur on these steels is briefly discussed, and use of zirconium sulphide is considered in detail; free-machining corrosion-resisting steel is described and its properties enumerated.

Quenching. Effect of Quenching and Tempering on the Hardness and Impact Resistance of a High Chromium-Silicon Steel, F. T. Sisco. Am. Soc. Steel Treating—Trans., vol. 14, no. 6, Dec. 1928, pp. 859–865, 6 figs. Result of investigation on quenching and tempering temperatures on alloy steel containing 1.2 per cent carbon, 1.2 per cent silicon, and 18.0 per cent chromium; best quenching temperature was found to be 1800 to 1850 deg. fahr.; steel retains its hardness at all temperatures below 1000 deg. fahr.; Izod impact values are low and are but little affected by varying tempering temperatures.

CLUTCHES

Electromagnetic. Electromagnetic Clutches, Forster Type (Embrayage électro-magnetique systéme Forster), R. Minicus. Génie Civil (Paris), vol. 93, no. 22, Dec. 1, 1928, pp. 524–526, 4 figs. Description of Forster clutch; advantages of electromagnetic clutches and their application in power plants; details of installation at Farneta and Ligonochio plants in Italy.

COAL

Carbonization, Low-Temperature. Technology of Low-Temperature Carbonization, F. M. Gentry. Mech Eng., vol. 50, no. 12, Dec. 1928, p. 970. Review of book published by Williams and Wilkens Co.; book lays great stress on technology; it deals with origin and constitution of coal with theory of coking by external and internal heating and also with thermochemistry; concluding chapter goes into financial side of low-temperature carbonization and investigates conditions which must exist to make it a pecuniary success; main part of book is followed by complete bibliography which contains 413 up-to-date references.

Distillation, Low Temperature. The "Babcock" Low-Temperature Coal Distillation System. Gas Jl. (Lond.), vol. 184, no. 3417, Nov. 14, 1928, p. 469. Plant, which has been installed at Dunston power station, has been in continuous operation for various long periods extending over past three years; complete plant is capable of distilling about 100 tons of coal per day; means have been provided whereby required proportion of hot products of combustion may be obtained by any of following methods; combustion of powdered fuel, of producer gas, and of coke-oven gas.

Pulverizers. Coal Pulverizers, W. J. A. London. Am. Soc. Mech. Engrs.—Advance Paper, no. 47, for mtg. Dec. 3–7, 1928, 7 pp., 11 figs. While there are two principles of attrition and impact on which pulverizing mills are based, there are such radical differences of design as to raise question of correct fundamentals; guarantees are given on performance when engineering problems are difficult of determination with any degree of accuracy; analysis of what actually takes place in mill leads to suggested design.

CONVEYORS

Motor-Truck Plants. Short Conveyors in Making Trucks, F. L. Prentiss. Iron Age, vol. 122, no. 23, Dec. 6, 1928, pp. 1425–1429, 7 figs. Power conveyors for progressive assembling of motortruck chassis recently installed by White Motor Co., Cleveland, are described; 12 distinct truck models manufactured on one assembly unit and also many departures from standard design made; handling heavy pieces from machine to machine on rollers or by monorail; devices used in assembling; special racks for special parts; assembling engine on conveyor; frames put together in three lines.

CRANES

Cable, Design of. The Design of a Cable Crane (Berechnung eines Kabelkrans), J. M. Bernhard. Foerdertechnik und Frachtverkerr (Wittenberg), vol. 21, nos. 18 and 21, Aug. 31, and Oct. 12, 1928, pp. 321–324 and 382–384, 10 figs. Description of new type of Bleichert cable crane for conveyance of coal to boiler house of steam-electric power station; computation and design of cables, counterweights, supports, steel frames, etc.

Jib, Steam. A New Steam Jib Crane. Engineer (Lond.), vol. 146, no. 3800, Nov. 9, 1928, p. 528, 1 fig. Crane constructed by Bedford Eng. Co. has capacity of 3½ tons at 30 ft. radius and is intended largely for use in connection with grab, but will also be employed for handling ordinary loads.

CUTTING TOOLS

Alloys for. Cutting Alloys Affect Tool Design, E. F. DuBrul. Iron Trade Rev., vol. 83, no. 23, Dec. 6, 1928, pp. 1442 and 1444. Description of two new alloys for cutting tools, developed by Krupp Steel Works and General Electric Co., precedes discussion of three bulletins issued by National Machine Tool Builders Association dealing with effect of introduction of new cutting alloys; research program suggested; future market for machine tools; warn-

ing as to what might happen if industry does not meet situation now facing it.

Lubricants for. Cooling and Lubrication of Cutting Tools. Am. Soc. Mech. Engrs.—Advance Paper, no. 44, for mtg. Dec. 3–7, 1928, 10 pp. Progress report no. 1, of sub-committee on cutting fluids, of A.S.M.E. Special Research Committee of Metals. Brief survey of current practice in selection of cutting fluids for respective operations and various materials to be cut, based upon information received from number of leading metal-cutting plants in United States; outline of recent experimental work; chart for tabulating current shop practice in use of cutting fluids is appended. Bibliography.

CYLINDERS

Hollow, Buckling of. Plastic Buckling of Walls of Hollow Cylinders and Some other Collapse Phenomena in Shells and Sheets (Plastisches Knicken der Wandung von Hohlzylindern und einige andere Faltungserscheinungen an Schalen und Blechen), J. W. Geckeler. Zeit. fuer Angewandte Mathematik und Mechanik (Berlin), vol. 8, no. 5, Oct. 1928, pp. 341–352, 19 figs. Mathematical analysis of empirical data on collapse of shape of pipes, tanks, thin plates, etc.; theory of cupping and drawing of metal sheets.

D

DIES

Forging, Heat Treatment of. Heat Treatment of Die Blocks, J. W. Urquhart. Heat Treating and Forging, vol. 14, no. 8, Aug. 1928, pp. 852–855 and 862. Comparison of methods employed in England with those standard in United States; carburized plain and nickel-steel die block; chromium-steel die tools difficult to machine; shock-resisting nickel steels; author points out that presence of nickel in chromium steels serves to retard grain growth during prolonged heating at high hardening temperatures. See article in Metallurgist (Supp. to Engineer, Lond.), Oct. 26, 1928, pp. 153–154, referring to Am. Soc. Steel Treating report and to above article.

DIESEL ENGINES

Air-Injection. Injection Air Regulation, S. G. Welbury. Gas and Oil Power (Lond.), vol. 24, no. 278, Nov. 1, 1928, pp. 23–24, 5 figs. New means of regulating injection, or blast, air in air-injection Diesel engine is explained; regulation is performed quite automatically, quantity of air passing from air bottles to spray valves being regulated indirectly by governor in direct proportion with load on engine; thus almost uniform mixture of fuel oil and air in cylinders will result at all loads of engine.

Large. Large Diesel-Engine Plants (Grossdieselmotoren-Anlagen), M. Gercke. Waerme (Berlin), vol. 51, no. 43, Oct. 27, 1928, pp. 801–804, 6 figs. Author discusses three main applications of large Diesels, namely: ship drive, drive of electric generators in power plants with continuous operation, drive of generators for peak-load service and for reserve power in standby plants; limitations of different types; examples of actual installations.

Performance Testing. A Simple Method of Comparing Oil-Engine Performances, O. Nonnenbruch. Am. Soc. Mech. Engrs.—Advance Paper, no. 23, for mtg., Dec. 3–7, 1928, 4 pp., 11 figs. Author analyzes tests made on Diesel engines to determine fuel consumption per brake horsepower-hour per indicated horsepower-hour; friction load in all cases is constant over whole load range, and fuel consumption per indicated horsepower-hour at low indicated mean effective pressures is practically same for all types; possible to derive indicated fuel consumption and indicated horsepower of engine from brake fuel-consumption tests without indicator cards.

Pulverized-Fuel. Diesel Engine Operated Four Years on Powdered Coal, H. Schreck. Motorship, vol. 13, no. 12, Sec. 1, Dec. 1928, p. 1000. This particular engine, originally M.A.N. Diesel, was converted for purpose by installing new cylinder head and another fuel cam; fuel used was brown coal with content of 10 per cent ash and 12 per cent moisture, supplied to engine through vertical pipe; cost of fuel is reduced to about one-third of that of fuel oil.

Sulzer Double-Acting. The Sulzer Double-Acting Diesel Engine. Power Engr. (Lond.), vol. 23, no. 272, Nov. 1928, pp. 419–421 and 432, 2 figs. Description of large-size engine; power is largest yet obtained from single cylinder; cylinder diameter is 900 mm., or about 35½ in., and piston stroke, 1400 mm.; engine develops 24 b.hp. at 100 r.p.m.; two vertical double-acting scavenging pumps are arranged at forward end; supercharging pump is driven tandem fashion, off each scavenging-pump piston tail road; air supplied to engine at pressure of 11 lb. per sq. in. above atmospheric pressure.

DISKS

Rotating, Stress Analysis in. Stress Distribution in Rotating Disks of Ductile Material After the Yield Point Has Been Reached, A. Nadai and L. H. Donnell. Am. Soc. Mech. Engrs.—Advance Paper, no. 22, for mtg. Dec. 3–7, 1928, 8 pp., 10 figs. Study of distribution of stress in rotating disk of ductile material (of uniform thickness, with and without central hole) after yield point has been passed; curves are computed showing growth of "plastic" region at different speeds, until whole disk has become plastic; general methods are developed, and applied to examples for finding complete distribution of stresses and strains in such disks.

E

ELECTRIC FURNACES

Annealing. Electric Heat Anneals Magnetic Iron. Elec. World, vol. 92, no. 20, Nov. 17, 1928, pp. 1002–1003, 1 fig. Quality and uniformity are assured in magnetic iron produced by Automatic Electric, Inc., Chicago, Ill., by use of electrically heated annealing furnaces; full automatic control is obtained through use of time clocks, which at predetermined hour establish control circuit through Leeds and Northrup potentiometer record controllers.

Heat-Treating. Conveyor Type Electric Furnaces, A. H. Vaughan. Heat Treating and Forging, vol. 14, no. 11, Nov. 1928, pp. 1328 and 1331–1332, 5 figs. Five principal varieties of devices for propelling material to be heated through electric furnaces are discussed with reference to practical installations; they include: (1) suspension conveyors using chains or other carrying means located outside furnace; (2) roller hearth-type furnaces with mechanical travel rolls; (3) apron conveyor similar to ones ordinarily used for bulk material handling; (4) belt conveyors using flexible metal belt for carrying material; (5) modifications of apron conveyor referred to above.

High-Frequency. Induction Melting Furnace Producing Steel. Heat Treating and Forging, vol. 14, no. 11, Nov. 1928, pp. 1324–1325, 2 figs. Description of 600-lb. high-frequency Ajax Northrup furnace installed at plant of Heppenstall Forge and Knife Co., Pittsburgh; installation is first in United States to cast steel in ingot form; h.f. current is generated in 150-kva. General Electric motor-generator set.

ELECTRIC WELDING

Resistance. Welding Low-Resistance Metals, P. T. Van Bibber. Am. Mach., vol. 69, no. 24, Dec. 13, 1928, p. 925. Difficulties in electric resistance welding of copper, brass, silver, and platinum; heating effect controlled to considerable degree by resistance of joints and this accounts for variation in quality of welding of pieces identical in shape; variation in power-line voltage also serious drawback; with some commercial spot welders modifications in transformer necessary.

F

FANS

Performance Characteristics. Ratio of Opening of Fan Performance in Terms of Direct Pressure Quantity Relations, G. E. McElroy. Am. Soc. Heat and Vent. Engrs.—Jl., vol. 34, no. 11, Nov. 1928, pp. 783–793, 2 figs. Writer has been particularly interested in mine fans; determination and calculation of direct pressure-quantity relation for mines and mine airways; new constant for expressing orifice pressure losses; ratio of opening; chart for determining ratio of opening; charts for fan selection.

FIRE EXTINGUISHERS

Foam. Testing and Maintenance of Fire Foam Solutions, J. B. Rather and D. P. Weld. Am. Petroleum Inst.—Advance Paper for mtg. Dec. 3–6, 1928, 20 pp., 6 figs. Fire foam solutions consist, in general, of solutions of sodium bicarbonate and aluminum sulphate, one or both containing material to stabilize foam; enumeration of stabilizing materials; typical formula; characteristics of good foam; conditions affecting nature of foam; analysis of solutions; stability tests; penetration tests; reconditioning solutions; graphs and tabular data.

FLOW OF AIR

Ducts. The Resistance to the Flow of Air in Ducts in Relation to Their Size and Shape, H. Eisert. Am. Soc. Heat. and Vent. Engrs. Jl., vol. 34, no. 11, Nov. 1928, pp. 795–806, 3 figs. Formula developed by K. Brabbée and published in 6th edition of his "Heizungs und Lueftungstechnik," merits consideration; attempt is made to point out merits and possibilities of this formula when applied in design of ventilating system; example to demonstrate practical application of diagrams.

FLOW OF LIQUIDS

Submerged Jets. Discharge Characteristics of Submerged Jets, M. J. Zucrow. Purdue Univ.—Eng. Experiment Station vol. 12, no. 4, June 1928, 64 pp., 21 figs. Report deals with discharge characteristics of submerged square-edged and chamfered jets which were calibrated with chemically pure benzol; dimensional treatment of flow through jet; description of apparatus; outline of investigation. Bibliography.

FLOW OF WATER

Orifices. An Investigation of the Coefficients of Discharge of Circular Orifices on the End of a Pipe, R. H. Brigham. Wis. Engr., vol. 33, no. 1 Oct. 1928, pp. 12, 26 and 28. Need of information that would show relation of discharge of orifice so located and its coefficient as related to standard conditions of head, size of pipe, and size of orifice; investigates and determines coefficients of discharge of standard sharp-edged orifices on end of 6-in. wrought-iron pipe under heads of from 1 to 60 ft. of water and discharging freely into atmosphere; method of operation.

FORM-TURNING MACHINES

Proportional. Proportional Form-turning Machines, O. S. Marshall. Machy. (N. Y.), vol. 35, no. 4, Dec. 1928, pp. 264–266, 3 figs. Form-turning machine employed in production of wooden shoe lasts is described; it can be set to turn shoe lasts of same size and shape as master, or, by proper adjustment of proportional mechanical movement mechanism, it can be made to form lasts longer or shorter than model, as well as thicker or thinner; machine can be readily adjusted for turning either left-foot or right-foot shoe lasts from same model.

FOUNDRIES

Automobile Plants. New Continuous Molding Unit Reduces Studebaker Foundry Costs, G. A. Gunther. Automotive Industries, vol. 59, no. 21, Nov. 24, 1928, pp. 756–759, 9 figs. Continuous molding and sand conditioning unit installed in South Bend Plant of Studebaker Corp. is described; production speeded up and operations brought under closer control by chain belt installation; 70 tons of sand are being handled per hour, and 850 transmission cases, and nearly 300 flywheel housings are being produced per 9-hour day; 29 molders, 11 shake-out men, and three for pouring.

FOUNDRY PRACTICE

Metal Mixing. Melting Metals. M. G. Francis. Brass World, vol. 24, no. 11, Nov. 1928, p. 336. Consideration of manner to procede in production of alloy; more perfect union between components is secured by agitation of contents with stirring rod, most effect being wooden or carbon rod which promotes admixture without introduction of substances likely to contaminate mixture or modify properties; author has used deoxidizing agents such as boronic copper or phosphor copper as purifying agents for removing oxides.

FURNACES

Heat-Treating. Furnaces for Various Heat Treatments, P. C. Osterman and E. C. Cook. Heat Treating and Forging, vol. 14, no. 9, Sept. 1928, pp. 1066–1069 and 1086, 21 figs. Many types of heating machines are described and illustrated, bringing out progress that has been made in mechanization of heating operations; means worked out for conveying work through heated space; early types of machines.

G

GAGES

Drill, Optical. Bausch & Lomb Optical Drill Gage. Machy. (N. Y.), vol. 35, no. 4, Dec. 1928, pp. 310–311, 1 fig. Description of optical drill gage by means of which drills can be checked to determine location of point or apex

in relation to axis of drill, to see if cutting lips are inclined at same angle relative to drill axis, and to determine whether web is central relative to drill axis.

Tapers, Measuring. A System for Measuring Tapers. Am. Mach., vol. 69, no. 24, Dec. 13, 1928, pp. 907–911, 10 figs. Application of new system for accurate measurement of master gages for cartridge and gun chambers, worked out by Winchester Repeating Arms Co., is described; system applicable to other taper gages; gagemaker should be furnished with definite dimension measurements not eliminated in finishing of gage and further available for check after gage is in service.

GEARS

Design. Gear Tooth Breakage, Wear and Noise, A. B. Cox. Machy. (N. Y.), vol. 36, no. 4, Dec. 1928, pp. 290–292, 2 figs. Three essential requirements of gearing; usual ways of obtaining great tooth strength; load on one tooth of single-tooth contact gears; "integral-contact" gears designed so that two pairs of teeth are always in contact; pointed tooth as strong at tip as at root; when errors in form or spacing occur; integral-contact gears wear so as to correct tooth form. Abstract of paper presented at Production Meeting of Soc. Automotive Engrs.

Manufacture. Metallurgical Problems of Transmission Gearing, E. F. Davis. Am. Soc. Steel Treating—Advance Paper, for mtg. Oct. 8–12, 1928, 23 pp., 12 figs. Action of gear teeth in mesh described with reasons why tooth failures cannot always be attributed to metallurgical defects; stages in manufacture of good gears; attributing elements in success or failure of final products; many items often ignored are actually vital elements in manufacture of quiet running transmission units; modern furnace installations used in gear industry; different methods for heat treating gears.

Metallurgy. Metallurgical Problems of Transmission Gearing, E. F. Davis. Am. Soc. Steel Treating—Trans., vol. 14, no. 6, Dec. 1928, pp. 831–852 and (discussion) 853–858, 12 figs. Paper describes action of gear teeth in mesh and demonstrates why tooth failures cannot always be attributed to metallurgical defects; review of various stages in manufacture of good gears and attributing elements in success or failure of final products; brief description of modern furnace installations used in gear industry and advantages and disadvantages of different methods for heat-treating gears.

Testing Machines. Gleason Combination Lapping and Testing Machine. Machy. (N. Y.), vol. 35, no. 4, Dec. 1928, p. 303, 1 fig. Details of 18-in. combination testing and lapping machine developed by Gleason Works, Rochester, for use in production of spiral-bevel and hypoid gears; gears are first tested in this machine after being cut, to determine tooth bearing; after hardening, they are again tested, both for bearing and noise; brake on gear or driven head enables gears to be tested under load.

GRINDING WHEELS

Segmental. Segmental Grinding Wheel, F. Horner. Machy. (N. Y.), vol. 35, no. 3, Nov. 1928, pp. 185–189, 15 figs. Production of large ring wheels not economical; principal precautions in designing segmental wheels; avoiding breakage of segments on Norton wheels; Norton segmental chuck; chuck with segments positioned for shearing cut in wheel of Bridgeport Safety Emery Wheel Co.'s face grinder; segmental wheels of five English concerns; conical-shaped chuck; segmental wheels with ring adjuster sold by Carborundum Co.

H

HARDNESS TESTING

Cloudburst Process. Cloudburst Process for Hardness Testing and Hardening, E. G. Herbert. Am. Soc. Steel Treating—Advance Paper, no. 16, for mtg. Oct. 8–12, 1928, 16 pp., 15 figs. Four functions of cloudburst process of bombardment with hard steel balls discussed; elimination of soft articles or articles having soft spots; measurement of hardness and its control between limits; superhardening of hard steel; production of work-hardened surface on steel, cast iron, and other metals; steel work-hardened surface can be further increased in hardness by annealing at temperature between 200 and 300 deg. cent.

HEAT TRANSMISSION

Graphical Treatment of. A Graphical Treatment of Heat-Exchange Problems, J. S. Stepanov. Am. Soc. Mech. Engrs.—Advance Paper, no. 31, for mtg. Dec. 3–7, 1928, 7 pp., 8 figs. Author applies graphical method to investigation of certain heat-transfer problems; equations and diagrams are given for handling heat-transfer problems pertaining to surface heat exchangers and direct-contact heat exchangers, using counter-current and parallel flow of substances, their applications in general calculations and investigations, and in analysis of experimental data.

HIGH-SPEED STEEL

Heat Treatment. Heating High Speed Steel to 2400 Degrees Fahr. in Molten Lead, W. C. Searle. Am. Soc. Steel Treating—Trans., vol. 14, no. 6, Dec. 1928, pp. 927–930 and (discussion) 930–931, 3 figs. Paper describes apparatus and method of heating steel to 2300 to 2400 deg. fahr. in molten lead; photomicrographs show structure obtained in specimens at 2200, 2300, and 2400 deg. fahr.

HOBS

Design. The Design of Hobs for Taper-Threaded Joints, E. Buckingham. Am. Mach., vol. 69, nos. 20 and 21, Nov. 15 and 22, pp. 759–763 and 801–803, 4 figs. Nov. 15: Analysis of forms produced by hobbing both members of joint with tapered hob having straight-sided teeth applies also to any hobbed thread; service which tapered threaded tool joint must perform; some problems involved in production of these joints described; necessary values for thread on pin are determined. Nov. 22: Analysis of thread includes side cutting and height of fillet at both ends of hob as well as influence of rake on hob teeth.

HONING

Machines and Process. Progress in Honing-Machines and the Honing Process, C. G. Williams. Soc. Automotive Engrs.—Jl., vol. 23, no. 6, Dec. 1928, pp. 561–567, 8 figs. Description of honing machines and process, as applied to finishing automobile engine cylinders, is preceded by description of early methods of finishing cylinders; machines driven by electric motors and have spindles reciprocated hydraulically; important superiorities to grinding; experiments indicate honing rough-cast surfaces may become successful operation; one great problem has been obtaining stones of correct grit; time-saving; honing Diesel cylinders.

HYDRAULIC TURBINES

Propeller-Type. Propeller-Type Waterwheels Have Adjustable Blades. Power, vol. 68, no. 23, Dec. 4, 1928, pp. 917–920, 5 figs. Chippewa Falls, Wis., hydroelectric development provides 21,600-kw. additional power from Chippewa River; plant has 6 units and operates in water synchronism with 39,000-kw. Wissota development 2 miles above; uses propeller-type turbines with movable blades that may be adjusted to maintain maximum results under varying operating conditions; hydraucone draft tubes used; waterwheels drive 4000-volt 3-phase 60-cycle vertical generators with direct-connected 50-kw. 250-volt exciters.

I

INDUSTRIAL MANAGEMENT

Cost Accounting. Depreciation as it Affects Costs, T. B. Frank. Am. Mach., vol. 69, no. 21, Nov. 22, 1928, pp. 789–791. Outline of several important depreciation factors to be considered in determining costs in machine-building plants; fair selling prices can be set only when depreciation and interest on invested capital are taken into account; depreciation defined; valuation of equipment should allow for cost of reproduction.

Cost Reduction. Practical Ways to Cut Cost. Factory and Indus. Mgmt., vol. 76, no. 5, Nov. 1928, pp. 942–944, 7 figs. Suggestions are given out of experience of seven manufacturers; clearing orders quickly; handling should be made easy; spraybooth housekeeping; removing tramp metal; minimizing fire hazards; scrap reclamation; expense of rehandling.

Measurement. A Basis for Evaluating Manufacturing Operation, L. P. Alford and J. E. Hannum. Am. Soc. Mech Engrs.—Advance Paper, for mtg. Dec. 3–7, 1928, 7 pp. Man-hours worked is proposed as basis for evaluating certain factors in manufacturing operations, as productivity, labor permanence, fixed-capital investment, primary power, industrial accidents, costs, profits, and selling price; consideration and interpretation of these factors as revealed by analysis of records of over 13,000 plants, employing nearly 2,000,000 workers in 100 industries.

Production Control. Procedure of the Shop Manufacturing Orders, W. Gordon. Wood Worker, vol. 47, no. 9, Nov. 1928, pp. 37–38, 1 fig. Definite and systematic procedure should be devised to take care of all orders from time they are received until finished product leaves factory; backbone of such procedure is manufacturing order which, to be effective, should give a glance essential information necessary to get job through plant with least amount of confusion; shop being considered is jobbing type.

Psychology and Production, H. E. Taylor. Automobile Engr. (Lond.), vol. 18, no. 248, Nov. 1928, pp. 461–463, 3 figs. Human element in modern production schemes; mechanical systems of production and control; function of technical section in bringing about amicable relations between capital and labor overlooked; three types of mentality in industry; application of psychological principles; radical change required in methods of casting; experiments with unit continuous system; simple matter to maintain lead if efficient production methods and humanics are studied. Paper read before Instn. Production Engrs.

Time-Study Instruments. Modern Time-Study Instruments (Neuzeitliche Hilfsmittel bei Zeitaufnahmen und Betriebsueberwachung), K. H. Fraenkel and W. Eckenberg. Maschinenbau (Berlin), vol. 7, no. 22, Nov. 15, 1928, pp. 1052–1059, 28 figs. Description of tape chronographs and other special instruments for recording of time of operations.

United States. The Race Between Production and Distribution, C. S. Ching. Management Rev., vol. 17, no. 4, Apr. 1928, pp. 111–116. Notes on democratic character of American management; fallacy of old economic doctrines; cause and remedy of unemployment; present maladjustment which has resulted in some unemployment needs serious consideration by management, for if remedy is not found growing feeling may be expected that improved methods are by no means unmixed blessing; this may in turn result in opposition toward these improvements which will definitely check progress.

INDUSTRIAL PLANTS

Location. Why We Moved to a Smaller Town, I. Salomon. Factory and Indus. Mgmt., vol. 76, no. 5, Nov. 1928, pp. 910–913, 3 figs. Author suggests points to consider in choosing new plant site; nearness to market and source of materials; transportation; labor conditions; banking facilities; fire protection; building costs; community facilities; liability of town to weather conditions; purity, sufficiency and cost of water; cost of fuel and power; cost of surrounding land in case of expansion; taxes and assessements.

INDUSTRIAL TRUCKS

Electric, Articulated Tilting. Articulated Tilting Truck. Automotive Industries, vol. 59, no. 23, Dec. 8, 1928, pp. 842–843, 1 fig. Details of storage-battery truck which will load 10-ton packages of sheet steel into box cars without breaking through car floors, made by Baker-Raulang Co.; Type D-96 is articulated or hinged in center enabling it to make very short turns from loading dock through 6-ft. car door with packages as large as 48 by 102 in.

Lift, Skid Platforms and. The Special Platform Widens the Field of the Lift Truck, G. E. Squier. Indus. Eng., vol. 86, no. 12, Dec. 1928, pp. 624–626, 8 figs. Platforms to handle almost every conceivable load that has to be moved over floor in modern factory.

INTERNAL-COMBUSTION ENGINES

Failures. Gas and Oil Engine Breakdowns. Mech. World (Manchester), vol. 84, nos. 2183 and 2184, Nov. 2 and 9, 1928, pp. 422–424 and 444–445. Nov. 2: Extracts from Technical Report issued by British Engine, Boiler, and Electrical Insurance Co.; failure of castings containing water when idle in frosty weather; failures of breech end and of combined cylinder jacket and bedframe; five examples of failures of crankshafts. Nov. 9: Three examples of serious damage resulting from failure of connecting-rod bolts, two cases of piston failures resulting in consequential damage.

Fuel Injection. New Process of Feeding Explosion Engines (Nouveau procédé d' alimentation des moteurs è explosion), F. Rochefort. Génie Civil (Paris), vol. 93, no. 17, Oct. 27, 1928, p. 410. Preparation mechanically of mixture partly gaseous by means of injector; gas-oil pulverized mixtures using carbureted air instead of pure air, furnished by engine itself; no carburetor is used.

Pulverized-Fuel. The Pulverized-Fuel Engine (Der Kohlenstaubmotor). Elektrotechnische Zeit. (Berlin), vol. 49, no. 41, Oct. 11, 1928, pp. 1507–1509, 1 fig. Notes on development of pulverized-fuel engines; first engine was single-cylinder, 4-stroke M.A.N. Diesel rebuilt by Kosmos for pulverized fuel; new engine, called

Rupa, after its inventor, is especially recommended for high-speed type; advantages over Diesel engine and other prime movers are cited.

Rochefort Cycle for. Thermodynamic Diagram of the Rochefort System (Sur le diagramme thermodynamizue due système Rochefort), J. Auclair and J. Villey. Académie des Sciences—Comptes Rendus (Paris), vol. 187, no. 17, Oct. 22, 1928, pp. 699–701, 1 fig. Study of cycle and theoretical diagrams of engine operating according to Rochefort system which permits analysis of combustion phenomena occurring in cylinder.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

IRON CASTINGS

Cleaning, Core Removal, etc. Removes Cores Hydraulically, J. Prendergast. Foundry, vol. 56, no. 22, Nov. 15, 1928, pp. 922–925, 7 figs. Development of hydraulic method for cleaning castings is outlined; methods of cleaning cores at Claremont, N. H., and Michigan City, Ind., plants of Sullivan Machinery Co., are described; accidents in cleaning department reduced by hydraulic method; fewer men required; cost of installation; expenses of operation and estimated yearly savings shown.

Defects. Some Causes of Sponginess on the Upper Surfaces of Iron Castings, T. Butterworth. Iron and Steel Industry (Lond.), vol. 2, no. 2, Nov. 1928, pp. 43–44 and 46. Causes of this vexatious defect are discussed in detail, and number of hints given to iron founders which will help them to combat nuisance; examination of spongy places; effects of air in mold and of pouring iron hot; pinhole defects; liberation of gases on solidification; heating of mold by metal gives good results; green sand molds more prone to sponginess.

J

JIGS AND FIXTURES

Design. Interchangeability and Its Relation to Jig and Fixture Design, J. M. Harrison. Can. Machy. (Toronto), vol. 39, no. 22, Nov. 1, 1928, pp. 30–32 and 71, 6 figs. Importance of jigs and fixtures and close relationship with subject of interchangeability; different types of jigs and principle involved in each; careful workmanship needed for box jigs; skeleton jig; six important factors which are involved in jig design; methods of holding work in place; snap and turnover jig.

L

LIQUIDS

Evaporation. The Change of State From Liquid to Vapour, H. L. Callendar. Engineering (Lond.), vol. 126, nos. 3278, 3279 and 3281, Nov. 9, 16, and 30, 1928, pp. 594–595, 625–627, and 671–673, 19 figs. Nov. 9: Theory of continuity of liquid and gaseous states is discussed. Nov. 16: Examination of properties of liquid up to critical point. Nov. 30: Discussion of van der Waals' theory of continuity of state between liquid and its vapor; co-aggregation theory has been verified by three independent methods, which all yielded results in close agreement.

LOCOMOTIVES

Development. Latest Types of Steam and Internal-Combustion Locomotives, H. Fowler and H. N. Gresley. Instn. Civil Engrs.—Introductory Notes (Lond.), Group 2, 1928, pp. 48–53. Most recent British practice as regards express passenger locomotives and powerful freight locomotives is given; engines worthy of mention; experimental engine No. 60,000 built by Baldwin Locomotive Co., Schmidt-Henschel high-pressure locomotive; Winterthur high-pressure locomotives; steam-turbine locomotives; Diesel locomotives; Kitson-Still locomotive.

Diesel. A New Diesel Locomotive Design. Ry. Gaz. (Lond.), vol. 49, no. 21, Nov. 23, 1928, pp. 652–653, 3 figs. Details of locomotive, recently constructed for use on Light Railways and Industrial Lines, and demonstrated on 1-ft. 11½-in. gage Welsh Highland Railway; locomotive is of 0–6–0 wheel arrangement; 4-stroke cycle McLaren Diesel engine has four cylinders, 200 mm. stroke by 135 mm. bore, capable of developing 60 b.hp.; transmission details; cab and controls.

Diesel-Electric. New Diesel-electric Locomotives for the Russian Railways, O. Schlaepfer. Brown Boveri Rev. (Baden, Switzerland), vol. 15, no. 1, Oct. 1928, pp. 298–299. Particulars of different locomotives; arrangement of axles and five nose-suspended tram-type motors; Russian Railways have decided to depart from usual type of Diesel-electric locomotive construction with tram-type motors and to adopt designs embodying motors mounted in frames, as motors can then be observed while locomotive is running; tests which are being conducted simultaneously on two locomotives will show which of designs is better and therefore more suitable to be used in future.

High-Pressure. High-Pressure Locomotive of Schwartzkopff-Loeffler System (Locomotive à haute pression système Schwartzkopff-Loeffler). Revue Générale des Chemins der Fer (Paris), vol. 47, no. 5, Nov. 1928, pp. 550–553, 2 figs. Description of Loeffler patented principles and how they are applied to steam system of locomotive.

High-Pressure Steam Locomotives (Une locomotive à vapeur a haute pression), R. Villers. Nature (Paris), no. 2796, Nov. 1, 1928, pp. 401–404, 6 figs. Description of high-pressure locomotive made by Société Suisse pour la Construction des Locomotives, at Winterthur; boiler and firebox; steam; engine has 3 coupled axles and weight of 75 tons.

Oil-Electric. Canadian National's New 2660-Hp. Oil-Electric Locomotive. Ry. Age, vol. 85, no. 23, Dec. 8, 1928, pp. 1125–1127, 3 figs. Locomotive, consisting of two units, weight 650 lb. when fully equipped, of which 480,000 is carried on driving wheels; each unit contains Beardmore 12-cylinder oil engine of solid injection type, 12-in. bore and 12-in. stroke; nominal rating of engine is 1330 hp. at 800 r.p.m.; engine develops rated horsepower at fuel rate of 0.43 lb. per b.hp.-hr.; exhaust heat aids oil-fired boiler to heat train; electric control apparatus; air brake equipment; expected performance.

Oil-Electric Locomotives in the United States, J. H. Harvey. Modern Transport (Lond.), vol. 30, no. 504, Nov. 10, 1928, pp. 13–14, 2 figs. Oil-electric traction used on Long Island Railroad is described; Westinghouse-Beardmore high-speed vertical 6-cylinder oil engine using solid injection and operating on 4-stroke cycle; 330 hp. developed at 800 r.p.m.; Westinghouse d.c. 600-volt, main generator and Westinghouse d.c. 64-volt, auxiliary generator; multiple operation of two oil engines; torque governor; indicator lamps and switches; engine accessibility.

Pulverized-Coal. Pulverized Fuel Locomotives, J. C. Armstrong. Engineer (Lond.), vol. 146, no. 3799, Nov. 2, 1928, pp. 495–497, 5 figs. Details of design worked out by A.E.G. and results of trials carried out by German railway authorities; fuel used was pulverized brown coal from Michel mines; advantages to be obtained by using pulverized fuel are enumerated; disadvantages of unit system; includes brief discussion. Paper read before Instn. Locomotive Engrs. See editorial comments on p. 490. See also description of same locomotive in Eng. and Boiler House Rev., vol. 42, no. 2, Aug. 1928, pp. 72, 74–75 and 78.

Valve Gears. Valve Gear With Independent Cut-Off and Exhaust. Engineering (Lond.), vol. 126, no. 3279, Nov. 16, 1928, pp. 616–617, 5 figs. Valve motion was designed largely to overcome high compression in locomotive cylinders at high speeds; results of tests on stationary engine proved thoroughly satisfactory; invention of J. T. Marshall comprises main steam valve, with expansion valve on back of it, and independent exhaust valves, all actuated by gear having separate expansion and reversing links of slotted type. For similar description see Power Engr. (Lond.), vol. 23, no. 273, Dec. 1928, pp. 464–465, 4 figs.

M

MACHINE SHOPS

Glass-Walled. A Shop With Walls and Roof of Glass, F. H. Colvin. Am. Mach., vol. 69, no. 19, Nov. 8, 1928, pp. 717–719, 6 figs. General description of machine shop of Hall Planetary Co. is given after consideration of factors that affect both employees and production; novel construction; entire walls and roof are of special actinic, corrugated-wire glass; all exposed metal is copper, brass, or lead.

MACHINE TOOLS

Exhibition, London. Machine Tool and Engineering Exhibition at Olympia. Ry. Engr. (Lond.), vol. 49, no. 585, Oct. 1928, pp. 353–360 and 364, 15 figs. Wide range of machine tools on view, covering types employed in variety of industries; examples of machinery adaptable for locomotive and railway rolling-stock building and maintenance operations; railway axle lathes shaping, and slotting machines; novel system of drive, radial drilling machine, all-geared horizontal milling machine, double-ended axle journal grinding machine, rapid-production boring, etc., are described.

Recorders. Automatic Work Recorders for Machine Tools (Selbsttaetige Leistungsueberwachung an Werkzeugmaschinen), M. Kronenberg. Werkstattstechnik (Berlin), vol. 22, no. 21, Nov. 1, 1928, pp. 597–600, 4 figs. Describes automatic circular recorder designed for registering working time, speed of revolution, and cutting speed.

MALLEABLE CASTINGS

White-Heart. Whiteheart Malleable Tests, E. R. Taylor. Foundry Trade Jl. (Lond.), vol. 30, no. 640, Nov. 22, 1928, p. 373. Discussion of thin-walled malleable-casting tests; test bar of similar cross-section to actual work in hand would be most appropriate; in this case, test bars and articles they represent could be annealed together in efficient manner; manufacturer of thin-walled goods would be enabled to carry out tests for tensile strength, elongation and bend, which at present are often omitted owing to unsuitability of standard test bar; engineering malleable castings meeting B.E.S.A. specification are satisfactory. From Brit. Cast Iron Research Assn.—Bul., Oct. 1928.

MATERIALS HANDLING

Automobile Plants. Report on Material Handling. Soc. Automobile Engrs.—Jl., vol. 23, no. 6, Dec. 1928, pp. 628–629. Progress in handling transportation, storage and fabrication of materials in automobile industry is reviewed by Materials Handling Subcommittee of Production Committee; eliminating stockrooms; shipping sheet steel; increased demand for special trucks; various applications of roller, scrap, and chain conveyors, overhead track, and electric trucks.

Forge Shops. Materials Handling Procedure in a Forge Shop, A. Caddie. Can. Machy. (Toronto), vol. 39, no. 23, Nov. 15, 1928, pp. 42 and 44, 3 figs. Physical layout of machines and furnaces in forge shop is discussed; group arrangement costly from materials-handling point of view; routing of definite piece of material described under both group and unit plans of layout.

Human Element in. The Human Element in Relation to Intermittent Mechanical Handling, G. F. Zimmer. Indus. Mgmt. (Lond.), vol. 15, no. 10, Oct. 1928, pp. 336–340, 3 figs. Continuous conveyors of any of standard types perform only one operation; crane operation; driver; human machine; influence of sport on executives training; capacities of conveyors; unloading vessels; vertical skip hoist.

Skid Platforms in. Economic Aspects of the Shipments of Materials on Skid Platforms, C. B. Crockett. Mech. Eng., vol. 50, no. 12, Dec. 1928, pp. 937–939, 3 figs. Paper presents economic aspects of above method viewed purely from standpoint of shipper or receiver of material; method is described as to equipment, its uses, and relation to manufacturing processes; comparison is made between total cost of physical distribution and cost of freight transportation only, pointing out small influence of latter factor in total cost; field of savings is discussed; possible growth of system and four main factors which may influence its more general adoption.

MEASURING INSTRUMENTS

Precision. Carl Zeiss' Precision Measuring Machine, G. Scherr. Instruments, vol. 1, no. 11, Nov. 1928, pp. 483–484, 2 figs. Construction is based on entirely new optical principle, whereby micrometer screws as well as devices for controlling their rather excessive measuring pressure have been eliminated entirely; in their stead only glass scales are being used together with optical indicator; these glass scales will not wear and therefore retain their original accuracy indefinitely.

METALS

Flow. The Flow of Metals (Das Fliessen der Metalle), G. Sachs. Zeit. fuer Metallkunde (Berlin), vol. 20, no. 9, Sept. 1928, pp. 334–336, 2 figs. Abstract of report on effect of average main stress on flow of metals, previously indexed from Forschungsarbeiten Auf dem bebiete des Ingenieurwesens (Berlin), no. 303.

Hardening. Cold and Hot Working of Metals, W. Rosenhain. Metallurgist (Supp. to Engineer, Lond.), Oct. 26, 1928, pp. 152–153. Consideration of fact that even in harder metals of high melting point temperature is reached where metal no longer undergoes hardening as result of plastic deformation; author defines term by which state or condition of solid matter which is not truly crystalline can be denoted; hardening effect in all cases is regarded as de-

pending upon retention of deformed crystal lattice in distorted or strained condition by resistance to return movement on part of those atoms which are brought into irregular (non-lattice) arrangement.

Plastic Deformation. Plastic Deformation of Metals (Studien ueber bildsame Verformungen der Metalle), F. Koerber. Stahl und Eisen (Duesseldorf), vol. 48, no. 41, Oct. 11, 1928, pp. 1433–1441, 20 figs. Results of studies carried out at Kaiser-Wilhelm-Institut fuer Eisenforschung; cold and hot working; formation of flow-curves; recrystallization under influence of forging and rolling; changes in structure; macroscopic, microscopic, sub-microscopic, and X-ray investigations were carried out.

Testing. Long Duration Tensile Tests on Metals at High Temperatures, E. Honegger. Brown Boveri Rev. (Baden), vol. 15, no. 11, Nov. 1928, pp. 315–320, 7 figs. Discussion of early tests on metals at high temperature precedes description of Brown Boveri apparatus for making long duration tests; specimen enclosed in tubular electrically heated muffle; maximum load was 5000 kg.; ball bearings used throughout; measurements taken on particularly elastic metals also; method of testing outlined.

MILLING MACHINES

Design. Theory of Milling Process (Zur Theorie des Fraesvorganges), C. Salomon. V.D.I. Zeit. (Berlin), vol. 72, no. 45, Nov. 10, 1928, pp. 1619–1624, 12 figs. Precise mathematical analysis including solution of heretofore unsolved milling integral; relation between depth of cut and rate of feed, effect of length of diameter and of number of teeth.

O

OIL ENGINES

Double-Acting. Fiat Two-Stroke Cycle Double-Acting Oil Engine. Power Engr. (Lond.), vol. 23, no. 273, Dec. 1928, pp. 465–467, 2 figs. Single-cylinder experimental engine of 2000 b.hp. 150 r.p.m., which employs steel castings extensively in interests of lightness; bore of cylinder is 33.1 in., while stroke is 39.4 in.; tension through-bolts pass from upper cylinder cover to underside of bedplate, thereby relieving cylinder jacket and framing tensile stresses.

Oil-Spraying Systems. Characteristics of Oil-Spraying Systems Investigated, C. W. Hicks and C. S. Moore. Automotive Industries, vol. 59, no. 21, Nov. 24, 1928, pp. 760–761, 3 figs. Study of oil injection in internal combustion engines, made by N.A.C.A.; cam-operated fuel-injection pump and centrifugal-type, spring-loaded, automatic injection valve used to inject fuel into light-tight compartment, spray being observed with oscilloscope; injection lag in crank-degrees decreases with increase of engine speed at constant fuel quantity. From Nat. Advisory Committee for Aeronautics—Tech. Memo., No. 298.

OPEN-HEARTH FURNACES

Design. Elements in Construction of Furnaces. Iron Age, vol. 122, no. 21, Nov. 22, 1928, pp. 1294–1296. Review of discussion dealing with elements in construction of open-hearth furnaces, at Pittsburgh meeting of Open Hearth Committee of American Institute of Mining and Metallurgical Engineers; water cooling of furnaces; charging equipment; accounting for repair costs; organization of plant; keeping mud out of steel; Loftus brick keeps clean; Stevens open-hearth furnaces; value of large furnaces.

ORIFICES

Discharge Through. Discharge Coefficients of IG Measuring Orifices for Water, Oil, Steam, and Gas (Durchflussbeiwerte der IG-Messmuendungen fuer Wasser, Oel, Dampf und Gas), R. Witte. V.D.I. Zeit. (Berlin), vol. 72, no. 42, Oct. 20, 1928, pp. 1493–1503, 51 figs. Report from physics laboratory of I.-G. Farbeinindustrie Aktiengesellschaft on results of Lappe's calibration of rounded orifices and sharp-edged diaphragm orifices of pipes, from 50 to 500 mm. in diameter; comparative calibration data of V.D.I. and I.G. orifices and nozzles.

P

PIPE LINES

Pressure Rise in. New Aspects of Maximum Pressure Rise in Closed Conduits, S. L. Kerr. Am. Soc. Mech. Engrs.—Advance Paper no. 17, for mtg. Dec. 3–7, 1928, 11 pp., 12 figs. Paper discusses various elements entering into determination of true maximum rise in pressure which may occur in closed conduits; contrary to usual belief, maximum rise in pressure will not necessarily be produced when full flow in given conduit is cut off, but is function of initial flow from which deceleration starts; comparison is made of computation by several accepted methods based on elastic-wave theory, and translation of important studies made by M. Gariel in France is included; summary of water-hammer computations.

PISTON RINGS

Twin Type. An Ingenious Twin Piston Ring. Engineer (Lond.), vol. 146, no. 3799, Nov. 2, 1928, p. 497. New and simple form of piston packing ring has been invented by Lancaster and Tonge, Manchester, who claim that it is greatest improvement in rings since Ramsbottom took out his patent in 1844; for steam-engine pistons one set is sufficient for ordinary pressures, but for air-compressor pistons two sets in two grooves are fitted; for gas and oil-engine pistons it is recommended that groove nearest explosion chamber be fitted with twin ring, other grooves being fitted with usual plain ring.

PLANERS

Metal-Working. Evolution of Planing Machines (Entwicklung der Hobelmaschinen), Weil. V.D.I. Zeit. (Berlin), vol. 72, no. 47, Nov. 24, 1928, pp. 1720–1723, 10 figs. Description of systems of driving with one and two belts, electric motors, etc.; lubrication, control, etc.

POWER PLANTS, DIESEL

Economy of. The Oil Engine's Part in Reducing Power Costs, L. H. Morrison. Factory and Indus. Mgmt., vol. 76, no. 6, Dec. 1928, pp. 1108–1110, 3 figs. Diesel plant costs from $100 to $150 per kilowatt of capacity; this is about same as steam plant but much more than cost of turbine to go into plant having serviceable boiler; consequently Diesel has so far not replaced old steam plant but is going into new plants only; oil engine is one of present-day prime movers that offer escape from power costs; it is efficient, reliable, and has long life.

POWER PLANTS, ELECTRIC

Remote Control of. Modern Apparatus for Remote Control and Remote Measurements (Neuzeitliche Fernsteuer- und Messeinrichtung), F. Heide. Zeit. fuer Fernmeldetechnik (Munich), vol. 9, no. 9, Sept. 29, 1928, pp. 129–135, 8 figs. Principles and general scheme of construction of remote-control apparatus of 10 or more switches.

POWER PLANTS, HYDROELECTRIC

Automatic. Automatic Hydroelectric Central Stations (Les centrales hydroélectriques automatiques), P. d'Audeville. Technique Moderne (Paris), vol. 20, no. 19, Oct. 1, 1928, pp. 633–639, 6 figs. Describes equipment of central stations operated from distance automatically and shows operating and financial advantages of such installations; classifies stations and describes those equipped with synchronous machines.

California. 2562-Ft. Head Developed. Elec. World, vol. 92, no. 15, Oct. 13, 1928, pp. 724 and 733–734, 6 figs. Plant of Feather River Power Co., known as Bucks Creek plant, in northern California has installed capacity of 40,900 kw. and required investment of $7,500,000 to develop water supply of 300 sec-ft. under effective head of 2350 ft.; it is highest-head plant on North American continent; two penstocks 4800 ft. long; of 2100 ft. of triple riveted steel pipe at upper end; and 2700 ft. of Ferrum banded steel pipe with inside diameter of 36 in. at lower end.

Two 56,000-Hp. Impulse Units Utilize 2418-ft. Heated at Big Creek 2-A. Elec. West, vol. 61, no. 5, Nov. 1, 1928, pp. 256–262, 12 figs. Description of hydraulic features of fifth of Big Creek chain of power houses of Southern California Edison Co.; total rated waterwheel capacity of 112,000 hp. in two generating units; Shaver Lake reservoir is formed by gravity dam across Stevenson Creek 183 ft. high, 2222 ft. along crest and 123 ft. thick at base; penstock; convertible generating units operate at speed of 250 r.p.m. (50 cycles) under effective head of 2290 ft.; one unit was designed by Allis-Chalmers Co. and other by Pelton Water Wheel Co.

Louisville, Ky. Hydro-Electric Development at the Falls of Ohio, H. G. Roby. West Soc. Engrs.—Jl., vol. 33, no. 11, Nov. 1928, pp. 573–580. Example of water-power development that is put out of commission by oversupply of water instead of shortage; review of events that led to adoption of combined project; location of dam; principle governing design of dam; propeller type of waterwheel runner; maximum head is 37 ft.; full automatic control of units is provided.

Pumped-Storage. Pumped-Storage Hydro-Electric Plants, W. W. K. Freeman. Am. Soc. Civil Engrs.—Proc., vol. 54, no. 9, part 1, Nov. 1928, pp. 2457–2475, 5 figs. Near New Milford, Conn., is installed first modern plant in America to pump water into reservoir with off-peak power, in order to produce on-peak power later; principle of operation of such plants is explained, with discussion of their economic justification; points out extremes in physical features and advanced stage of development of this type of hydroelectric development; description of most interesting pumped-storage plants are included, particularly those which are adaptations of existing developments. Bibliography.

POWER PLANTS, STEAM

Equipment. Description of Principal Apparatus and Most Recent Installations of Modern Boiler Plants (Déscription des principaux appareils et des plus récentes installations de la chaufferie moderne). Technique Moderne (Paris), vol. 20, no. 21, Nov. 1, 1928, pp. 757–792, 68 figs. Description of apparatus and manufacture of boilers, mechanical grates, pulverized-coal equipment, economizers, air heaters, pumps, smoke removers, water distillation, soot blowers and regulating instruments made by various companies in France.

Modern Boiler Furnaces, Boilers and Accessories (La chaufferie moderne: chaudiéres et accessoires), C. Roszak. Technique Moderne (Paris), vol. 20, no. 21, Nov. 1, 1928, pp. 697–700. Discussion of evaporators, grate, and auxiliaries and condensing group; steam generators, driers, superheaters, water reheaters, economizers, and heat accumulators are described, also grates, air reheaters, dust collectors, soot blowers, condensers.

High-Pressure. The Age of High-Pressure Steam (Das Zeitalter des Hochdruckdampfes), St. Loeffler. V.D.I. Zeit. (Berlin), vol. 72, nos. 39 and 40, Sept. 29, and Oct. 20, 1928, pp. 1353–1360 and 1503–1509, 32 figs. Principles of high-pressure steam engineering with pressures as high as 120 atmospheres; Schmidt-Hartmann, Benson, and author's high-pressure steam-circulating process; safety of author's process; details of steam-circulating power plants of Vienna Locomotive Works and Witkowitz Metallurgical Works in Czechoslovakia.

POWER PLANTS, STEAM-ELECTRIC

Brooklyn, N. Y. Features of 110,000 Kw. Unit at Hudson Ave., J. N. Landis. Power, vol. 68, no. 20, Nov. 13, 1928, pp. 800–803, 4 figs. Description of station of Brooklyn Edison Co., with 110,000-kw. turbo-generator set and 85,000-sq. ft. single-pass condenser, largest operating equipment of that type; turbine is Westinghouse cross-compound machine, designed for 400 lb. pressure, 700 deg. total temperature and two stages of feed heating; served by four Westinghouse underfeed-stoker-fired Babcock & Wilcox boilers of 23,830 sq. ft. heating surface equipped with 14,960 sq. ft. return-bend type economizers.

110,000-Kw. Unit Operating at Hudson Avenue, J. N. Landis. Elec. World, vol. 92, no. 22, Dec. 1, 1928, pp. 1081–1085, 3 figs. Brooklyn Edison Co. has started operation of turbo-generator set with attendant equipment; largest machine of its kind with flat water-rate curve served by four boilers; novel stokers and hydraulic sluicing air-removal jets and extraction heating used; details of installation and heat balance chart.

Long Beach, Calif. 100,000-Kva. Edison Steam Unit. Elec. West, vol. 61, no. 5, Nov. 1, 1928, pp. 272–277, 10 figs. Largest single-shaft steam-electric generating unit ever to be constructed; first unit of Southern California Edison Co. Long Beach No. 3, steam plant; main generator is 100,000-kva. 16.5-kv. machine operating at 1500 r.p.m.; all high-tension equipment is mounted out of doors; 16.5/220-kv. bank of Westinghouse transformers; installation of water-spray nozzles for purpose of regularly washing 220-kv. insulators; control house has been provided for centralized control of plant; extensive use of automatic controls.

Peak Loads. The Peak-Load Problems in Steam Power Stations, A. G. Christie. Mech. Eng., vol. 50, no. 12, Dec. 1928, pp. 914–920, 14 figs. Use of load-duration curve for purpose of studying annual peak loads is analyzed and conclusions drawn that plant intended for annual-peak-load service should only be installed at lowest possible first cost and that economy of peak-load equipment can be sacrificed to secure low initial cost.

PRESSES

Forging, High-Speed. High-Speed Forging Presses. Mech. World (Manchester), vol. 84, no. 2184, Nov. 9, 1928, pp. 435-437, 3 figs. Description of forging presses of from 800 tons capacity up to those of 6000 tons capacity is given; comparison with steam hammer; utili-

zation of waste heat in forge plants, and need for discrimination.

PRESSURE VESSELS

Heads. Calculation of Conical Heads for Cooking Vessels Exposed to Internal Superpressure (Berechnung konischer Boeden von Kochgefaessen gegenueber innerem Ueberdruck), H. Thorgersen. Waerme (Berlin), vol. 51, no. 32, Aug. 11, 1928, pp. 587–588, 2 figs. Calculation of stress and strength of conical heads based on example of cooking vessel.

Design of Ellipsoidal Heads for Pressure Vessels, T. W. Greene. Am. Soc. Mech. Engrs.—Advance Paper, no. 48, for mtg. Dec. 3–7, 1928, 7 pp., 7 figs. Results of tests on propane storage tank 7 ft. in diam., 38 ft. 4 in. long, designed for working pressure of 200 lb. per sq. in., heads being ellipsoidal with 2-to-1 ratio of axes; author concludes that (1) heads with dish and large knuckle radii proportioned to closely approximate true ellipsoidal shapes with ratio of axes of 2 to 1, are far superior to flat dished heads with small knuckle radii; (2) stress distribution in such heads closely approximates that set forth by theory and formulas presented in paper can be safely used for design.

PUMPS, CENTRIFUGAL

Lift of. The Pumping Lift of Radial Centrifugal Pumps Logarithmic Spiral Blades (Das Foerderhoehenverhaeltnis radialer Kreisepumpen mit logarithmisch-spiraligen Schaufeln), A. Busemann. Zeit. fuer Angewandte Mathematik und Mechanik (Berlin), vol. 8, no. 5, Oct. 1928, pp. 372–384, 18 figs. Author gives mathematically more rigorous solution to problems discussed in previously indexed paper by W. Schulz in issue of Feb. 1928, pp. 10–17; graphical charts for solution of complicated equations derived by author.

Feedwater. New Turbine Boiler Feed Pumps of High Output (Neue Turbo-kessel-Speisepumpen groesserer Leistung), M. Knoerlein. Waerme (Berlin), vol. 51, nos. 40 and 41, Oct. 6 and 13, 1928, pp. 758–761 and 769–772, 14 figs. Principles governing construction of large turbine boiler feedwater pumps; description of new 600-hp. installation, including steam turbine with oil pressure gear and differential pressure regulation; pump with special arrangement for hot water.

R

RAILWAY MOTOR CARS

Internal-Combustion. A New Diesel-Electric Rail Car. Ry. Engr. (Lond.), vol. 49, no. 586, Nov. 1928, pp. 420–423, 4 figs. Description of car fitted with Beardmore 200-hp. quickrunning residual oil engine, coupled to English Electric tractiontype generator, and built for service on heavily graded line in Spain; accompanying drawings show how car is arranged; six-cylinder, four-cycle, simple fluid-type engine with pressure injection, and having cylinders $6^1/_2$-in. bore and 9 in. stroke; controlled by governor which regulated speed at all loads between 600 and 1250 r.p.m.

Motor Rail Cars with Internal-Combustion Engines (Automotrices sur rails à moteurs à combustion interne), Mellini and LaValle. Industrie des Voies Ferrées et des Transports Automobiles (Paris), vol. 22, no. 262, Oct. 1928, pp. 302–326, 11 figs. Report presented at 21st International Congress at Rome, May 1928; covers and kinds of car used in various countries in Europe and French colonies of North Africa.

REFRIGERATION

Ammonium Chloride Refrigerants. A Novel Refrigerating Agent, L. H. Lampitt and P. Bilham. Cold Storage (Lond.), vol. 31, no. 368, Nov. 15, 1928, pp. 359–361, 2 figs. Theory of eutectic mixtures; salient characteristics of eutectics; mention made of sodium chloride as forming eutectic with water, but many other salts may be used in this way; experiments with idea of determining most suitable for keeping ice cream; ammonium-chloride eutectic had greatest refrigeration effect for its weight. Paper presented before Brit. Assn. of Refrigerants.

ROLLING MILLS

Plate, Roll Failures in. Stresses in Hot Plate-Mill Rolls (Die Beanspruchung der Blechwarmwalzen), L. Weiss. Zeit. fuer Metallkunde (Berlin), vol. 20, no. 11, Nov. 1928, pp. 389–393, 13 figs. Causes of premature fracture and means of its prevention are discussed; heat-flow pressure values for iron, copper, and aluminum are shown graphically; also results of numerical calculation; determination of frequency of load changes for estimation of durability is recommended.

S

SAND, FOUNDRY

Testing. Molding-Sand Research (Formsanduntersuchungen), H. Nipper and E. Piwowarsky. Giesserei (Duesseldorf), vol. 15, no. 44, Nov. 2, 1928, pp. 1097–1108, 16 figs. Account of tests to determine influence of grain size and shape, clay content and moisture, on gas permeability of sand mixture; results are shown in graphic and tabular form.

SAWS

Cold. The Process of Cutting of Metals with Cold Saws (Der Schneidvorgang bei der Zerspanung durch Kaltkreissaegen), A. Wallichs and H. Hemscheidt. Maschinenbau (Berlin), vol. 7, no. 22, Nov. 15, 1928, pp. 1059–1064, 16 figs. Theoretical analysis and experimental verification of effect of saw-tooth characteristics on power consumption.

SCREWS

Automobile, Manufacture of. Cold-Worked Precision Screws in Automobile Manufacture (Kaltgeformte verguetete Praezisionsschrauben im Automobilbau), Valentin. Automobil-Rundschau (Berlin), vol. 30, no. 23, Nov. 12, 1928, pp. 598–599, 2 figs. Description of screw, put on market by Bauer and Schaurte A. G., known as Verbus screw; it is cold-pressed and then heat-treated, which gives it very uniform structure; finished product has strength of 80 kg. per cu. mm. with 16–10 per cent elongation.

SHEET-METAL WORKING

Waste Elimination in. Systematic Reduction of Scrap and Elimination of Waste in the Manufacture of Stamped Parts, J. K. Olsen. Metal Stampings, vol. 1, no. 5, Oct. 1928, pp. 347–350. Author deals with types of scrap and waste; points out modern methods of reducing waste, and advantages of periodic redesign of products; reduction of cost by standardization of material is effective.

SPRINGS

Helical, Stresses in. Stresses in Heavy Closely Coiled Helical Springs, A. M. Wahl. Am. Soc. Mech. Engrs.—Advance Paper, no. 39, for mtg. Dec. 3–7, 1928, 9 pp., 16 figs. More exact formulas are derived for computing stress in springs of type used frequently in railway work; formulas indicate that maximum stress in such springs may, in many cases, be from 40 to 60 per cent greater than stress computed by use of ordinary helical-spring formulas; formulas are verified by strain measurements, using special extensometers; frequent failures of this type of spring in service may, at least in part, be due to existence of higher stresses than thought possible on basis of ordinary spring formulas.

Research. Progress Report No. 4 of the A.S.M.E. Special Research Committee on Mechanical Springs, M. F. Sayre and A. Hoadley. Am. Soc. Mech. Engrs.—Advance Paper for mtg. Dec. 3 to 7, 1928, 17 pp., 24 figs. Report covers first year of investigation carried on by Committee at Union College, Schenectady, purpose of which is to examine fundamental characteristics of spring action; study of distribution of stresses in bending in spring steel at very high unit stresses; comparison of proportional limit and modulus of elasticity in bending and in tension at high and at low stresses; comparative internal friction in spring material in bending and in tension for varying stress ranges up to very high loads.

STEAM

High-Pressure. The Age of High Pressure Steam (Das Zeitalter des Hochdruckdampfes), S. Loeffler. V.D.I. Zeit. (Berlin), vol. 72, no. 45, Nov. 10, 1928, pp. 1638–1644, 16 figs. Discussion of firing with pulverized coal, intermediate super-heating, high-pressure steam engines, prospects of high-pressure steam.

STEAM METERS

Orifice. Orifice-Steam-Meter Coefficients, R. W. Angus. Am. Soc. Mech. Engrs.—Advance paper, no. 3, for mtg., Dec. 3–7, 1928, 3 pp., 7 figs. Description of tests conducted by author on steam turbine of 100-hp. which was not equipped with surface condenser; as it was connected to main header from large battery of boilers, feedwater method of measuring steam consumption was not available; orifice meter was used; coefficients under test conditions were all that were necessary, but it was decided to enlarge scope and determine them under wide range of conditions.

STEAM TURBINES

Blades. Tests of the Fatigue Strength of Steam Turbine Blade Shape, E. F. Moore, S. W. Lyon and N. J. Alleman. Univ. of Illinois—Bul., no. 183, vol. 26, no. 7, Oct. 16, 1928, 36 pp., 16 figs. Report of investigation conducted by Engineering Experiment Station in cooperation with Allis-Chalmers Manufacturing Co.; tests constitute study of strength of steam-turbine blade shapes of several different metals to resist many cycles of reversed bending stress; results of tests are believed to throw light on whether turbine blades under reversed flexure will withstand stresses as high as those indicated by fatigue tests of specially prepared specimens of metal in blades.

Heat-Balance Regulators. Automatic Heat Balance Regulation, J. J. Hoerath. Power, vol. 68, no. 24, Dec. 11, 1928, pp. 956–957, 4 figs. In order to maintain boiler feedwater temperature reasonably constant and to obtain close regulation, automatic load governor has been devised at Colfax power station of Duquesne Light Co.; consists of open chamber connected to closed chambers and governor loading weight floating on mercury that occupies half volume of chambers; this loading weight is attached to governor arm; closed mercury chamber is connected to exhaust of turbine; method of operation.

Impulse-Reaction. Recent Developments in the Design of Impulse-Reaction Steam Turbines, R. C. Allen. Elec. Jl., vol. 25, no. 11, Nov. 1928, pp. 534–537, 2 figs. Standard single-cylinder, single-flow design is at present used for ratings up to 65,000 kw. with four stages of feed heating; for capacities in excess of 65,000 kw. cross-compound construction is still to be preferred; effect of design on cost; features of design contributing to improved efficiencies; blading still greatest problem; operating characteristics.

STEEL

Alloy. See ALLOY STEELS.

Chromium. See CHROMIUM STEEL.

Cold-Drawn Testing. The Change in Tensile Strength Due to Ageing of Cold-Drawn Iron and Steel, L. B. Pfeil. Iron and Coal Trades Rev. (Lond.), vol. 117, no. 3161, Sept. 28, 1928, pp. 441–443, 1 fig. Describes experimental work on cold drawing of series of steels of varying carbon content and varying heat treatments, followed in all cases by tensile tests at different lengths of time after drawing; graph and tabular data of results.

Decarburization. Decarburization of High Carbon Steel in "Reducing" Atmospheres, J. J. Curran and J. H. G. Williams. Am. Soc. Steel Treating—Advance Paper, no. 15, for mtg. Oct. 8–12, 1928, 17 pp., 27 figs. Instances of soft skin in high-carbon steel parts which have been hardened under different commercial conditions, but usually when precautions were taken to minimize scaling; tests indicate that carbonaceous packing mixtures may be either carburizing or decarburizing in their action, depending on activating material used in mixture and on temperature of heat treatment packing materials used to protect steel probably responsible for softness. Bibliography.

Heat Treatment. Principles of the Heat Treatment of Steel. Am. Soc. Steel Treating—Trans., vol. 14, no. 6, Dec. 1928, pp. 893–926, 1 fig. Outline prepared by metallurgical staff of Bureau of Standards; case hardening; alloy steels; high-speed tool steel; heat treatment of other alloys; definition of heat-treating terms, Bibliography of 20 pp.

Surface Cooling of Steels in Quenching, H. J. French, G. S. Cook and T. E. Hamill. Am. Soc. Steel Treating—Advance paper, no. 11, for mtg. Oct. 8–12, 1928, 69 pp., 50 figs. Study of surface cooling of steel spheres when quenched in water, sodium-hydroxide solution, oils, or when cooled in air; effects of some of variables encountered in commercial heat treatment upon cooling of steel bodies; center and surface cooling curves obtained for pressure spray quenching with water are correlated with tensile and impact properties obtained in low-carbon steels, American ingot iron, and wrought iron.

High-Speed. See HIGH-SPEED STEEL.

Stainless. Rust, Acid and Heat-Resisting Steels, W. H. Hatfield. Am. Iron and Steel Inst.—Advance Paper for mtg., Oct. 26, 1928, 14 pp. Properties of series of steels, which are adequate to meet many conditions where rust, acids, or heat effects must be resisted, are discussed; production of rustless and acid-resisting steels should always be conducted under best technical control; possibilities of these steels will largely be governed by cost of production.

STEEL CASTINGS

Alloy, Heat Treatment of. Tentative Recommended Practice for the Heat Treatment of Alloy Steel Castings. Am. Soc. Steel Treating—Trans., vol. 14, no. 6, Dec. 1928, pp. 935–939. Recommended practice applies generally to commercial alloy castings for ordinary construction purposes and not for special use; chemical compositions of steel considered are given.

MECHANICAL ENGINEERING

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What It's All About

RESEARCH workers are always busy. Their wives will tell you that they forget their meals and prefer the laboratory bench to the bridge table. Bankers and industrialists impatiently await an opportunity to turn their researches into prosperity, and philosophers worry lest science and the machine destroy mankind. In good season the world learns of the discoveries.

The most important group of researches in steam reported in many years occupies a considerable space in the February issue of MECHANICAL ENGINEERING. This supplement explains in a few words the significance of this research and tells what the rest of the issue is about. After you have read it, pass it on to some one else. Let the world know what mechanical engineers are doing.

Progress in Steam Research

TWENTY-FOUR pages of the current issue of MECHANICAL ENGINEERING are devoted to researches on the properties of steam. To engineers this is not an overemphasis on a rather theoretical aspect of their calling, but a distinct achievement which has resulted through the cooperation of science and engineering, and which had its inception in the needs of industry.

Practice is always forging ahead of basic knowledge. A century and a half ago James Watt knew deplorably little about the properties of steam, and what he knew was only approximate; such as the crude rule that a cubic inch of water will make a cubic foot of steam. In spite of this he was responsible for the greatest invention in the history of the steam engine.

Watt's early work was with engines using steam at atmospheric pressure. There are still alive men who have operated engines on steam at 30 lb. per sq. in. pressure. Even comparatively young men can remember "high-pressure boilers" designed for steam at 70 to 100 lb. per sq. in.

But theorists have always pointed out the superior efficiency of engines operating with steam at high pressure and temperature, although until comparatively recently the necessity has not been sufficiently urgent to warrant the expense of the turbines and boilers for these conditions.

About eight years ago, designers being reluctant to produce turbines for high pressures because of their ignorance of the properties of steam, a group of research workers at Harvard, M.I.T., and the U. S. Bureau of Standards, cooperating under the auspices of the A.S.M.E. and with the help of the engineering industries, united to extend our knowledge of steam into the high-pressure regions. Working independently and on different phases of the problem, but in such a way that the results obtained by one would act as a check on those of the others, the researchers have proceeded to such a point that J. H. Keenan is able, in this issue, to present the principal data covering the entire range up to the critical pressure of 3200 lb. per sq. in. In a supplementary report which reviews similar work done by Knoblauch in Germany and Havliček in Czechoslovakia, Professor Keenan points out that the European investigators substantially corroborate the American work.

Besides the paper by Keenan, this issue contains the financial report of the Executive Committee of the Steam Table Fund by Geo. A. Orrok, a report of the M.I.T. work by Keyes and Smith, a report of that done at the Bureau of Standards by Osborne, Stimson, and Fiock, a comment by Dr. Davis, president of Stevens Institute, under whose direction the famous Harvard experiments were conducted, a summary of Knoblauch's work translated from his own paper, a comment on Keenan's paper with a comparison of his own and other investigations by Professor Havliček of the Masaryk Academy of Work, and a paper questioning the possibility of the existence of a single mathematical equation of state for steam over the entire range of pressures, by R. C. H. Heck of Rutgers, who has spent many years in a study of the various proposed formulations. Once again science has almost caught up with industry.

Some Famous Aeronauts

CLASSICISTS will remember Icarus, humorists, Darius Green, and contemporaries of the "gay nineties" will recall Professor Langley; but how many have heard of the contributions of Sir George Cayley to aeronautics? With most moderns, aeronautics is only twenty-five years old, and begins with the Wrights at Kitty Hawk. Even engineers, who realize that no great art springs full grown from the brow of Jove, need to be reminded of the history of aeronautics that antedates 1903.

In the current issue of MECHANICAL ENGINEERING, Col. V. E. Clark starts with Sir George Cayley's work in 1809 and outlines the important steps, to the present time, by which man taught himself to fly in heavier-than-air machines and passed from a sustained free flight of 12 seconds to one of 150 hours. Evidence seems quite clear that the lack of an adequate power plant was the greatest factor retarding the development of this new and important means of transportation. The recent epoch-making flight of the *Question Mark* seems to indicate that modern aeronautical power plants are reliable and suited to their task.

Turbo-Locomotives

FOR one hundred years the steam locomotive with its reciprocating pistons has been a familiar sight in this country. Except in a few localities where electric locomotives are used, and for a very few rail cars, no other types are known. The distinctive and explosive blasts of exhaust steam and smoke are as familiar as the screech

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